WEEKLY | NEWS IDEAS INNOVATION

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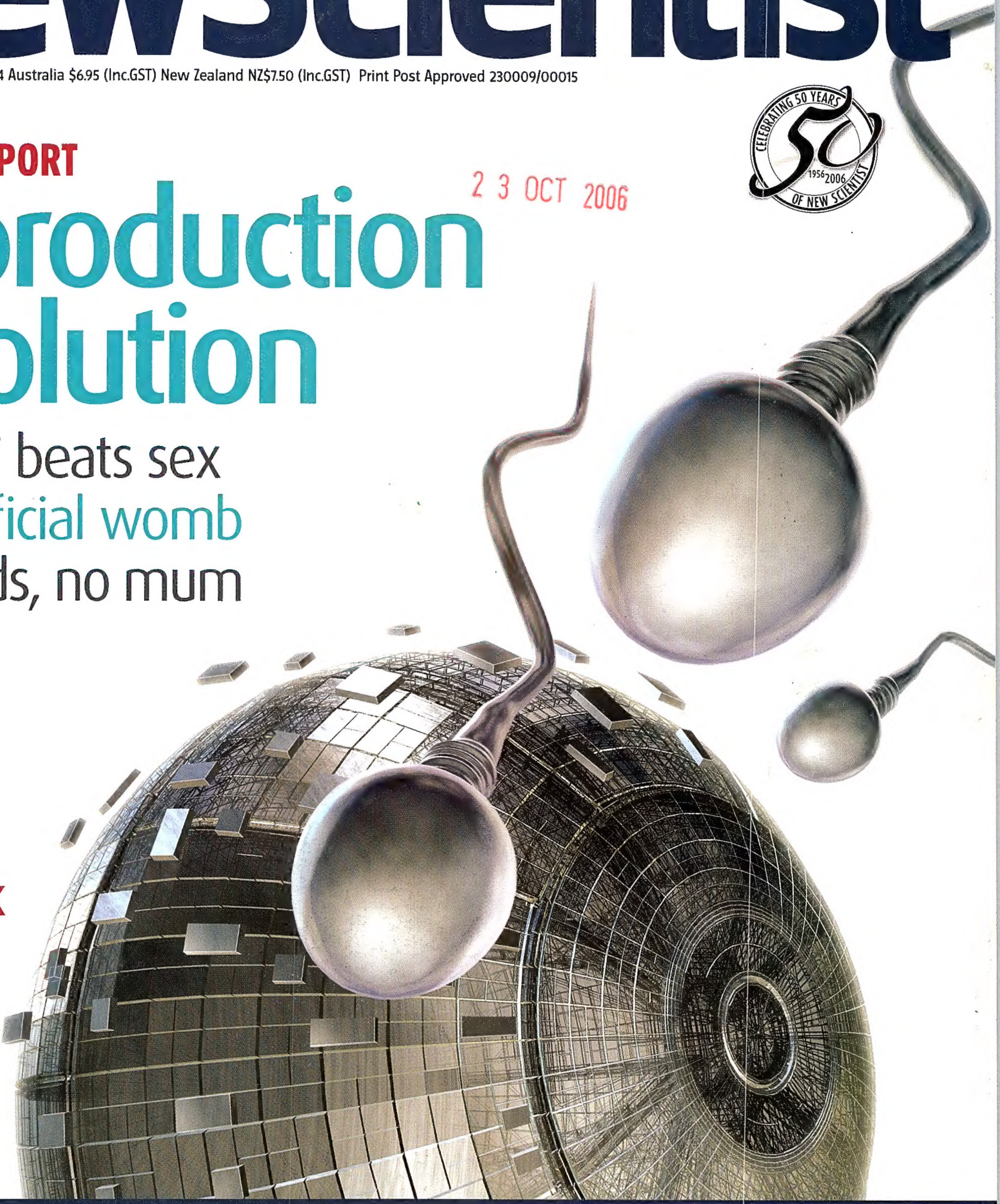
SPECIAL REPORT

Reproduction revolution

Why IVF beats sex
The artificial womb
Two dads, no mum



NIP & TUCK
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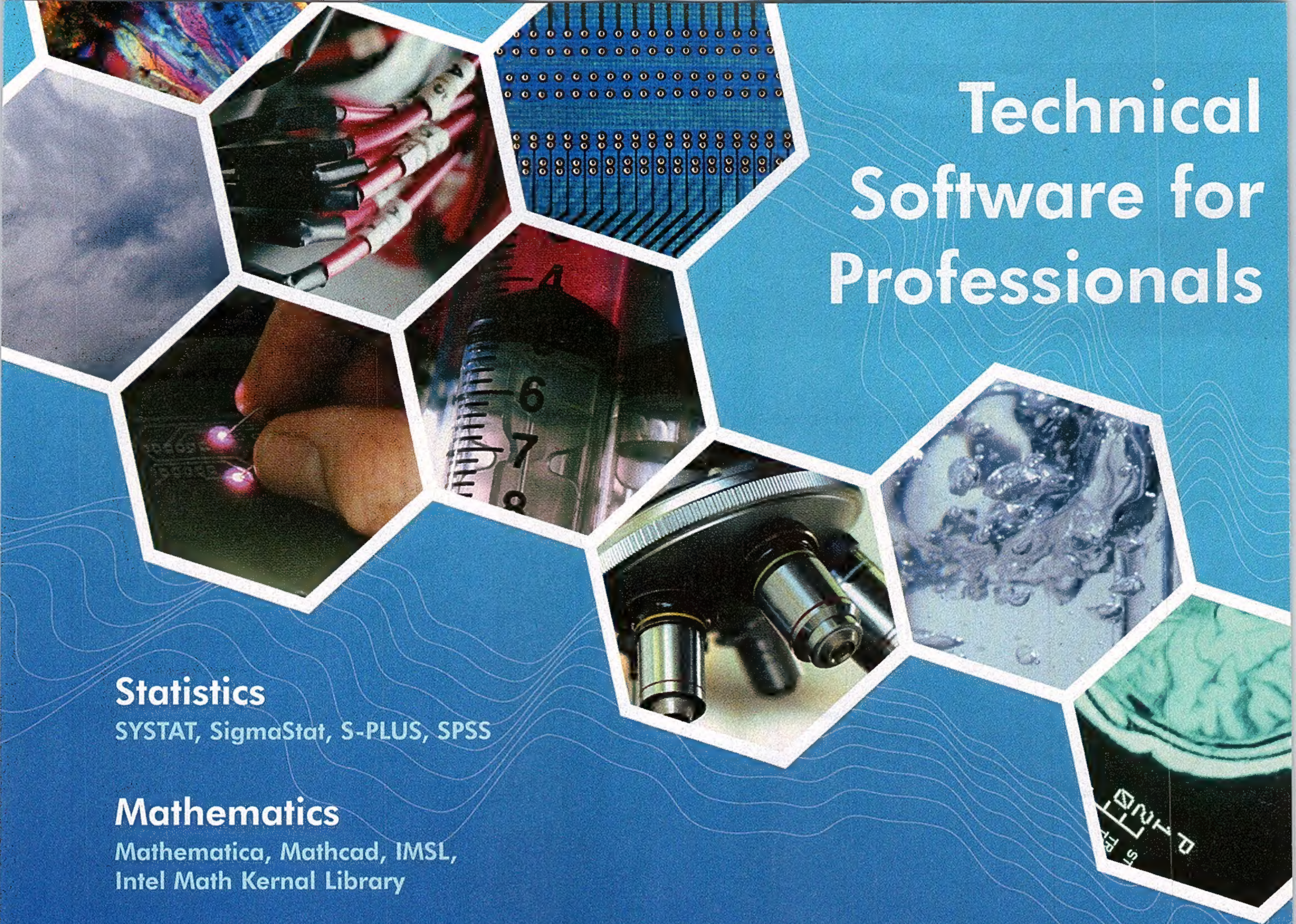

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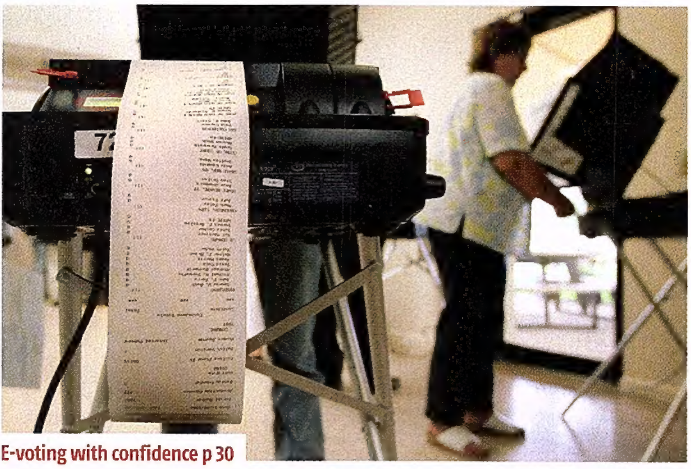

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> **"It is hard to see science education thriving in a nation whose leaders demonstrate an active disdain for the subject"**

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Beyond IVF

Should parents be free to decide what is acceptable?

A 66-YEAR-OLD woman gives birth. Children are born destined to be tissue donors for sick siblings. Women give birth to their own grandchildren, or to their nephew or niece. Children are conceived with the sperm of dead men. Babies are born with DNA from three "parents".

All these things have happened, and might even become routine as the reach of reproductive science continues to expand. Before long we may be able to screen embryos not just for disease-causing mutations, but also for desirable genetic characteristics. Egg freezing will allow women to delay having children until their forties or later. Gay male couples will be able to have their own biological children, at least with the help of a surrogate mother, while lesbians may be able to cut men out of the equation altogether (see page 52).

These advances in technology threaten to outstrip our ability to properly weigh up the ethical, social and biological consequences. The bewildering array of reproductive choices already raises profound and difficult questions, and governments have tended to respond to them in two ways: either by banning "undesirable" applications, as in the UK and Australia, or by leaving prospective parents to make up their own minds with the help of their doctors, as in the US. Whereas childbirth was once a sphere of human activity that democratic governments chose to leave well alone, it is now fair to ask whether they ought to intervene more, given the issues that reproductive science is raising.

The answer is far from straightforward. One good reason for banning certain reproductive practices is to protect the health of the resulting children. There is, for instance, clear evidence of the dangers of implanting multiple embryos, as this results in more twins and triplets who generally face greater health risks than singletons. Limiting the number of embryos that can be transferred, as many European countries do, is undoubtedly improving the prospects of children conceived by IVF. On the other hand, is it right to deny twins to parents who want them?

In the UK, the government-backed regulator goes further. Until recently, would-be parents in the UK could use pre-implantation genetic diagnosis (PGD) to screen only for fatal childhood diseases. The restrictions have now been relaxed, but parents are still denied the option of screening out many known disease-causing gene variants. It is also illegal in the UK to select an embryo on the basis of its sex, while in the US PGD can be used for whatever parents want and doctors will agree to, from sex selection to choosing deaf embryos. Though this latter option appals many, and has led to cries for government intervention, it is favoured by some deaf parents who consider themselves to be part of a community from which a hearing child would be barred.

> "Sex selection of embryos is illegal in the UK, while in the US PGD can be used for whatever parents want and doctors agree to"

Yet banning certain interventions is not the half of it. As screening techniques make it easier to discover what lurks in the family genome, might not prospective parents be morally obliged to have IVF-PGD to ensure that they are not passing on serious disease? Could choosing not to have IVF-PGD be tantamount to inflicting a disability on a child? Women have been prosecuted for drinking while pregnant; should couples who fail to ensure their children do not inherit genetic diseases also be punished?

That would be too extreme. Heavy-handed legislation is never likely to be the best answer to sensitive issues like these. In cases where governments foresee that a genetic technology might lead to a socially undesirable outcome, the carrot is likely to be more effective than the stick. For example, if parental choice is skewing the balance of the sexes, a suitable system of incentives could be used to restore it.

As we strive to find a path through this moral labyrinth, two things are worth remembering. First, the majority of these advances are beneficial, and promise people a better quality of life than their grandparents could have dreamed of. We should not reject them simply because they are novel. Second, there is no single solution. Deciding what is acceptable will take enlightened policy-making at every step, and open, informed public debate – which is what democratic politics is supposed to be about. Even then there are bound to be plenty of people who disagree. ●

Upfront

FERDINANDO SCIANNA/MAGNUM

Their feelings are hurt

THE MARK OF INSENSITIVITY

When soccer star David Beckham had the names of his children tattooed on his skin, thousands rushed to copy him. But Beckham may not have been revealing his sensitive side after all – a study of US college freshmen suggests that tattoos make the skin less sensitive to touch.

Todd Allen at the University of Northern Colorado in Greeley measured skin sensitivity in 54 people, 30 of whom had tattoos, using an aesthesiometer. This consists of two adjacent plastic points that can be moved further apart until a person senses them as two distinct points rather than one.

Allen tested participants' reaction to the aesthesiometer on five body parts: the lower back, the back of the calf, the inner forearm, the tip of the index finger and a cheek.

He found no difference between the sensitivity of the unmarked skin of tattooed individuals and that of their "uninked" counterparts, but tattooed areas appeared less sensitive than clear skin. For example, the tattooed region on one person's right leg was less sensitive than the corresponding tattoo-free area on the left leg.

There are many possible explanations, says Allen. The repeated stimulation of nerves during the tattooing process could desensitise them, or the ink injected into the skin may be interfering with the pressure of touch. Alternatively, the ink needles could cause direct damage to touch receptors. The findings were presented at a meeting of the Society for Neuroscience in Atlanta, Georgia, last week.

Iraq's body count

GREATER efforts are needed to measure the impact of war on civilians. That's the opinion of researchers at Johns Hopkins University in Baltimore, Maryland, who last week revealed that there have been between 400,000 and 950,000 "excess" deaths in Iraq since the start of the US-led invasion in 2003. Previous estimates based on hospital or military reports had put the number at less than 100,000.

Gil Burnham and colleagues interviewed nearly 13,000 people in 1849 households in Iraq, and found that death rates have climbed steadily since 2003, this year reaching four times the pre-war level. Most of the "excess" deaths were from gunshots or car bombs (*The Lancet*, DOI: 10.1016/S0140-6736(06)69491-9).

"Death rates in Iraq have climbed steadily since the US-led invasion in 2003"

An international body is urgently needed to monitor compliance with the Geneva Conventions, which prohibit attacks on non-combatants, the researchers conclude. "If you're going to improve protection, you have to start with the data," says Burnham. "But first, you have to work out how to get the information without being shot." He hopes aid groups will work together to better measure the impact of conflict on civilians.

Promoting the Geneva Conventions is one of the jobs of the International Committee of the Red Cross. "We remind governments of their obligations," an ICRC spokesperson said. But "we never do counts of victims". The ICRC also provides medical aid and visits detainees, so it needs to safeguard its access to war zones.

Tuna win respite

LIFE just got a bit better for embattled southern bluefin tuna in the oceans around south-east Asia. After Japan's admission that it had overfished the species by 1800 tonnes in 2005, the country's Fisheries Agency has agreed to halve its existing quota of 6065 tonnes to 3000 tonnes for at least five years, starting in 2007.

Conservationists welcomed the news, which was announced on 16 October in Miyazaki, Japan, following a summit held by the Commission for the Conservation of Southern Bluefin Tuna. But they are still concerned that the proposed cuts are not enough. WWF says that Australia's quota of 5265 tonnes should have been cut too. Virtually all of it ends up imported by Japan.

Overall, the summit nations agreed to a 20 per cent cut in the bluefin harvest, down to 11,530 tonnes from the 14,000 taken this year. Japan and Australia account for 80 per cent of the total catch.

Bluefin tuna are also declining in the Mediterranean, where France exceeded its 6192-tonne quota in 2005 by 3000 tonnes. The issue will be debated in November by the International Commission for the Conservation of Atlantic Tunas.

JONATHAN TORGOVNIK/CORBIS

Ah, sea air and asbestos

Not shipshape

SHOULD ships have hazardous substances removed before they are consigned to the scrap heap? Sounds like a no-brainer, but the answer is far from straightforward, as a controversial decision by the International Maritime Organization reveals.

Human rights campaigners have condemned the IMO's decision not to require pre-cleaning of ships, just as an Indian government report revealed that 1 in 6 workers scrapping ships in there show signs of the killer lung disease asbestosis.

It is one of the most dangerous industries to work in, says Paul Bailey of the International Labour Organization, especially as the vast majority of ships are now being scrapped in developing countries. As well as asbestos ships often contain PVC, heavy metals and antifouling agents.

Asbestos is legal to import and reuse in India. "They import hundreds of thousands of tonnes each year," says Bailey. Banning import and requiring pre-cleaning wouldn't help, he believes: owners would just take their ships elsewhere, so the responsibility must rest with them, he says.

Drop the c-word

DON'T say cloning, say somatic cell nuclear transfer. That at least is the view of biologists who want the term to be used instead of "therapeutic cloning" to describe the technique that produces cloned embryos from which stem cells can then be isolated. This, they argue, will help to distinguish it from attempts to clone a human being.

But will it? Kathy Hudson and her colleagues at the Genetics and Public Policy Center in Washington DC asked more than 2000 Americans whether they approved of deriving stem cells from embryos produced by cloning. For half of the sample they used the term "SCNT" instead of "cloning", and this raised approval ratings from 29 per cent to 46 per cent, Hudson told a meeting of the American Society of Human Genetics in New Orleans last week.

"Using the term 'SCNT' instead of 'cloning' dramatically raised approval ratings"

SCNT would also be used in any attempt to clone a human being, so Hudson also asked about creating babies using SCNT. This too raised the approval rate from 10 per cent to 24 per cent – which is not what scientists had in mind.

Lunar ice? No dice

MOONBASE planners hoping they might get oxygen and fuel as well as water from ice near the lunar poles have seen the idea melt away over the past two weeks.

Using the giant Arecibo radio telescope in Puerto Rico, Donald Campbell of Cornell University in Ithaca, New York, and colleagues have obtained the highest-resolution radar imagery ever of the shadowy craters near the moon's south pole thought to harbour ice. They report in *Nature* this week (DOI: 10.1038/nature05167) that unusual radar signals formerly attributed to water ice are also reflected from sunlit areas where ice could not survive. "There could be ice in small grains," Campbell told *New Scientist*, but thick deposits that could be a usable resource seem to be ruled out.

"Thick deposits of ice that could be a usable resource seem to be ruled out"

The same conclusion was reported a few days earlier by David Paige of the University of California, Los Angeles, whose team calculated temperatures around the lunar south pole and found that most of the "cold traps" could not be filled with ice.

SEEING RED BRINGS HUNGER

The four horsemen of the apocalypse are said to ride together. Now it seems that at least in the case of war, famine and death, it's true. That's the overwhelming message from a global analysis of malnutrition by the International Food Policy Research Institute.

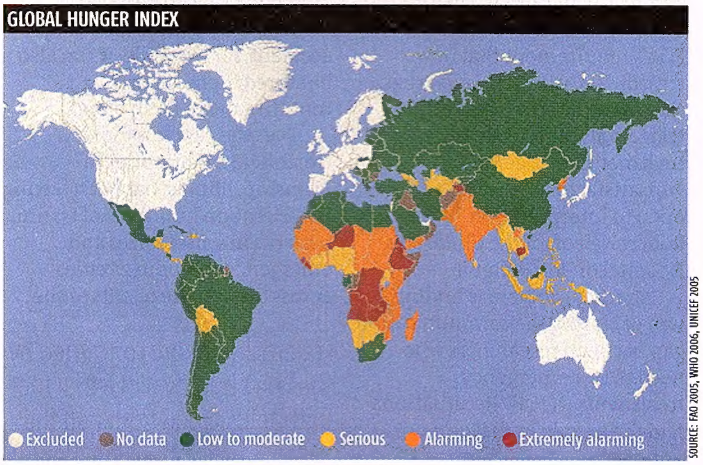
Perhaps unsurprisingly, nine of the 12 countries with the severest hunger were racked by civil war or violent conflict. Many of the countries that score worst are in sub-Saharan Africa, marked in red on the map.

"It demonstrates there should be a focus on conflict prevention and resolution," says project leader Doris Wiesmann. "But even under difficult conditions, investment in infrastructure, health and education can be beneficial."

Wiesmann says the analysis carries extra weight because the "global hunger index" that she used combines three major indicators of hunger into a single measurement – child mortality, child malnutrition and estimates of the proportion of calorie-deficient people in each country.

Wiesmann also found "hotspots" of hunger in south-east Asia, despite huge progress overall in the region thanks to the transformation of agriculture during the "green revolution" of the 1970s. These include parts of India, where women and children often go hungry because men traditionally get to eat their fill first, she says.

GLOBAL HUNGER INDEX



SOURCE: FAO 2005, WHO 2006, UNICEF 2005

60 SECONDS

Supersized element

By firing calcium-48 nuclei at a target made of californium-245, scientists at Lawrence Livermore National Laboratory in California have made element 118, the heaviest yet. The team claims 99.99 per cent certainty, based on three separate observations of the decay products of the 118 nucleus. A similar report by a different team in 1999 was later retracted.

Korea confirmation

US officials have confirmed that an underground detonation in North Korea was indeed a nuclear explosion of "less than a kiloton" in yield. The confirmation was based on radioactive by-products present in air samples gathered by American aircraft.

Calling the shots

The US military is to resume mandatory vaccination against anthrax for 200,000 troops in Iraq, Korea and Afghanistan. In 2004 a federal court ordered vaccination to be voluntary pending safety assessments, after many soldiers complained of serious side effects. The authorities now insist it is safe.

China's patent surge

Evidence of China's rapid technological expansion appears in a report showing that patent filings by Chinese residents soared fivefold to 65,786 between 1995 and 2004, according to an analysis issued by the World Intellectual Property Organization. China's patent office is now the fifth-largest in the world, behind Japan, the US, South Korea and Germany.

Food in the bank

Access to genes from the world's key food crops has been granted to plant breeders, farmers and researchers. The UN Food and Agriculture Organization marked World Food Day on Monday by signing agreements with agricultural research centres holding collections of around 600,000 plants. The aim is to ensure that the genetic resources these plants contain are conserved and sustainably used.

This week

CORBIS

An alternative to blood?

A life and death dilemma...

Who decides when to try controversial but potentially life-saving treatments on unconscious patients?

ANDY COGHLAN

IT IS a nightmare situation. Someone is unconscious in an ambulance following a heart attack or car smash. The paramedics have a treatment in their pack that just might buy them enough time to get to the emergency room. The trouble is it's brand new, experimental, and relatively untested. They clearly can't ask the victim for consent to use it. So what should they do?

Last week, the US Food and Drug Administration held a public hearing to review its guidelines for handling these life-and-death dilemmas. Up for discussion is how to meet the FDA's requirement that new treatments should be at least as safe as the alternatives and are tested only when existing treatments are deemed "unsatisfactory". "This is very open to interpretation," says Robert Nelson of the Children's Hospital of Philadelphia.

Another problem is finding a way of closing the communication gap between researchers who need to test emergency treatments in real-life situations and the people in the local population, upon whom this experimental treatment might be tested. This issue has been highlighted not least by the controversy surrounding trials of an artificial blood substitute called PolyHeme, designed to be used in an emergency in place of a blood transfusion.

PolyHeme is derived from haemoglobin, the oxygen-carrying pigment in blood, and because it is compatible with all blood types it can be given immediately at the scene of an accident, for example. It can also be stored for more than 12 months, unlike fresh blood.

Over the past few months, Northfield Laboratories of Evanston, Illinois, has been testing PolyHeme on hundreds of trauma patients in ambulances and emergency rooms in 25 cities across the US. The results of the trial are expected to be reported later this year.

"Patient groups are concerned by the FDA's approval of a trial that withholds blood from half the subjects in favour of PolyHeme"

Some patient advocacy groups are alarmed by the very nature of the current trial, which was approved by the FDA. "One of our specific concerns is the approval of a trial design that withholds conventional blood transfusion from half the subjects in favour of PolyHeme for 12 hours in hospital," says Elizabeth Woeckner of Citizens for Responsible Care and Research, a charity in Columbia, Maryland, which lobbies for patient safety.

While it may be justifiable for paramedics on the scene of an accident to give PolyHeme on the grounds that a transfusion is impossible, Woeckner argues that the equation changes once a patient is in hospital and a transfusion – the gold standard treatment for severe blood loss – is available.

"At this point the trial no longer meets conditions for waiver of informed consent," she says, because transfusion is not

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an "unproven or unsatisfactory" treatment.

She is not alone in her concerns. The Office for Human Research Protections, a federal agency within the Department of Health and Human Services that is charged with protecting patients, echoed these concerns in March in a public letter to the DHSS written by Iowa senator Charles Grassley, which claimed the hospital phase of the PolyHeme trial was "unethical".

The PolyHeme trial has also highlighted the problem of consent in cases where researchers want to test treatments in an emergency setting in a big city, where it is impossible to let everyone know that a treatment is on trial so they can actively opt out.

In the case of PolyHeme, researchers tried holding focus groups, town meetings and alerting people through the media, but their message seldom came to the attention of anyone except those who made a point of attending.

For these reasons, some of the groups that attended the FDA hearing last week are pushing for the creation of a national body to oversee clinical trials carried out in emergency situations. Such a body could provide expert advice to regulators at local level, who would then give final approval for the trial.

"A national advisory board that would pre-review protocols and serve as a resource for local IRBs had support from many presenters," says Michelle Biros, professor of emergency medicine at the University of Minnesota. But she said there was little support for a national body that would vet all proposals.

The FDA says that it will take all options seriously, including the potential for a new national body. "We'll look at all these proposals to see if we need to modify the regulations or guidance," said a spokeswoman, adding that the consultation closes in late November. ●

ACT FIRST, GET CONSENT LATER

In the UK, the government is poised to amend the law to make it easier for doctors to give experimental medical treatments in an emergency. "This would make it possible to enter an incapacitated person into a clinical trial involving emergency medicine before seeking consent from his or her legal representative," health minister Andy Burnham told the UK Clinical Research Collaboration in a letter on 22 September.

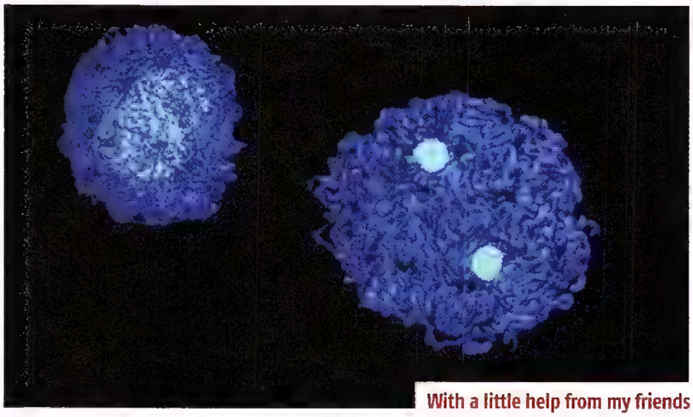
Such research has all but dried up in the UK because of rules introduced in 2004 in accordance with the European Clinical Trials directive 2001, which bans experiments on unconscious patients unless a "legal representative" such as a close friend or relative can be found to agree on their behalf, says Timothy Coats, chairman of the research committee of the College of Emergency Medicine.

"Valid consent requires time for explanation, questions, reflection and decision making," says a briefing document prepared by Coats and sent to the UK government last August. "In an emergency situation, there simply may not be time to go through this process."

Coats says that the net result has been "paralysis of the system". Only 7 of the National Health Service's 240 hospital trusts responsible for acute care in England and Wales have policies in place to accommodate the European rules, enabling them to legally take part in emergency medicine trials. As a result, British participation in pan-European trials has plummeted.

While 810 Britons were among the first 2500 to take part in the Europe-wide CRASH1 trial to treat head injuries with steroids, in the latest CRASH2 trial only 15 of the 2500 so far are British, says trial manager Haleema Shakur of the London School of Hygiene and Tropical Medicine.

Coats says many other European countries have interpreted the directive differently to allow research ethics committees to qualify as "legal representatives" able to provide consent in certain situations.



SCIENCE

With a little help from my friends

Stripped-down bacteria must pay for their keep

DEPENDING on your viewpoint it's either the ultimate in cooperation or it's slavery. The mitochondria that provide our cells with energy and the chloroplasts in plant cells that harness light energy were once free-living bacteria. After becoming symbiotic, hundreds of millions of years ago, they lost their ability to survive independently.

Now two species of bacteria that live in insects have been found in the process of transition from free-living organism to organelle. Their genomes are the smallest ever sequenced.

One of the bacteria, *Carsonella ruddii*, (see above) has the fewest genes of any cell known in the world – a mere 182, taking up about 160,000 base pairs of DNA. Humans have around 20,000 genes and 3 billion base pairs.

C. ruddii has lost many basic functions, including the ability to replicate independently; the host cell now takes care of that. The bacterium pays for its keep, however, supplying its sap-eating insect host with amino acids, including leucine (*Science*, DOI: 10.1126/science.1134196). Given what *C. ruddii* has lost, "it's just amazing that it has anything extra, even for the host", says Nancy Moran of the University of Arizona in Tucson, who led the research.

The other bacterium that has been caught in the process of becoming symbiotic relies on the hospitality of an aphid. *Buchnera aphidicola* bacterium has 362 genes and a genome 420,000 bases long (*Science*, DOI: 10.1126/science1130441).

C. ruddii relies on its host so heavily that it could qualify as an organelle. Moran does not call it this, however, because it exists in only a subset of cells in the insect. Organelles are found in all cells.

The findings show how few genes an organism needs to get by, but only when it can rely on help from a host. Earlier this year Anthony Forster of Vanderbilt University Medical Center in Nashville, Tennessee, and George Church of Harvard Medical School calculated that the theoretical minimum number of genes a cell needs is 151. The new results dramatically change the concept of a minimal bacterial genome, Forster says, and has implications for understanding the function of so-called "junk" DNA, which doesn't code for proteins.

"*C. ruddii* has lost many basic functions, including the ability to replicate independently. The host cell takes care of that"

"This organism contains almost no intergenic DNA, illustrating hat this so-called 'junk DNA' can be dispensed with," says Forster.

Rowan Hooper and Roxanne Khamsi ●

ANDREA ANGEL/ROSS WANLESS

Albatross chicks are falling prey to giant mice

Out of sight, out of luck

FRED PEARCE

GIANT mice are eating their way through one of the world's most important seabird colonies. An international airport is to be built on the only known home for 20 endangered insect species. Cats are harassing the Caribbean's endangered iguanas. And it's all happening on British territory.

The UK may have a good reputation for protecting endangered species within its own shores, but it is abjectly failing to do the same on its surviving fragments of empire in the Caribbean and the South Atlantic. That was the message from Biodiversity that Matters, a meeting of environmentalists working on the UK's 14 overseas territories, held on the Channel Island of Jersey last week. Delegates blamed government indifference for a frightening catalogue of invading species and unmet international obligations in these territories.

"The UK has more threatened wildlife on these islands than the whole of Europe put together. Yet while the government spends £500 million a year protecting biodiversity in Britain, it spends only about £1 million a year on its overseas territories," says Mike Pienkowski of the UK Overseas Territories Conservation Forum, which organised the meeting. "We need orders of magnitude more money to protect these places." He claims only five countries have presided over the extinction of more bird species.

Government scientists say UK overseas territories will fail to meet a pledge made at the World Summit in Johannesburg in 2002 to significantly reduce the rate of biodiversity loss by 2010. "The OTs are of huge importance globally in terms of biodiversity. Enhanced support for nature conservation is essential if the UK is to meet its World Summit commitment," says Marcus Yeo of the government's Joint Nature Conservation Committee.

However, Eric Blencowe of the environment department DEFRA, which funds most conservation work, warns that budgetary cuts are more likely. "The prospect of significant funding increase is unlikely in the near future."

The latest major threat is to Gough Island in the South Atlantic. Made a World Heritage Site in 1995, it is probably the world's most important seabird colony, according to Geoff Hilton of the UK's Royal Society for the Protection of Birds. But as Andrea Angel (pictured above) of the University of Cape Town in South Africa found, invading house mice have evolved to unprecedented size and are now eating thousands of chicks, including those of the endangered Tristan albatross and Atlantic petrel.

> "The UK spends £500 million a year protecting biodiversity at home, and about £1 million on its overseas territories"

Hilton forecasts a massive population crash among the island's birds unless the mice are exterminated, yet there is no money for such a programme, and the next scientific visit is not planned until September 2007.

Meanwhile the British government has decided to build a 2-kilometre airstrip on the tiny Atlantic island of St Helena, population 4000. The aim is to stimulate tourism and prevent emigration, but the runway will obliterate much of the habitat for 20 insects and spiders found nowhere else, plus one of three homes on the island for the last 220 St Helena plovers, the only survivor of six land birds that used to live there.

The conference also heard about a lost oil rig that beached on Tristan da Cunha in the South Atlantic in June, bringing shellfish that now threaten local ecosystems, and about rats running amok on South Georgia and Montserrat. There are also plans on the British Virgin Islands for a golf course across five rare salt ponds previously earmarked to become a national park. On top of that, cats are eating endangered iguanas on the Cayman Islands and Turks and Caicos Islands.

Even the handful of success stories highlights the ad hoc nature of the UK's care of overseas territories. Extermination of cats on Ascension Island is allowing seabirds to return to abandoned nesting colonies, but it only came about because a bird-watching civil servant spotted spare cash in the Foreign Office's budget. ●

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The last word

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BUBBLE SHAPES

was washing the dishes when I noticed that the bubbles in a splodge f soapy water on the counter had very regular structure. The bubbles, ll small and identical in size, had rranged themselves in patches of hexagonal lattices, very like a single heet of graphite. Even when ndividual bubbles burst, the lattices held their shape. The bubbles did not ouch as there was water between hem, so how did this structure ome about? Continued)

As an addendum to your earlier answer on bubble shapes, readers may like to know that floating rafts of oap bubbles on a dish of water were used by Nobel prize-winning physicist awrence Bragg and colleague John Nye in 1947 to simulate the packing of atoms in metallic crystals. Defects aused by missing atoms were simulated by simply popping one of he bubbles.

Len Fisher
Bradford-on-Avon, Wiltshire, UK

SHIFTING SANDS

How deep is the sand of the Sahara desert and what is directly beneath it? The Sahara is subject o considerable wind erosion and ts sand is found thousands of miles away. Is it replenished by some means?

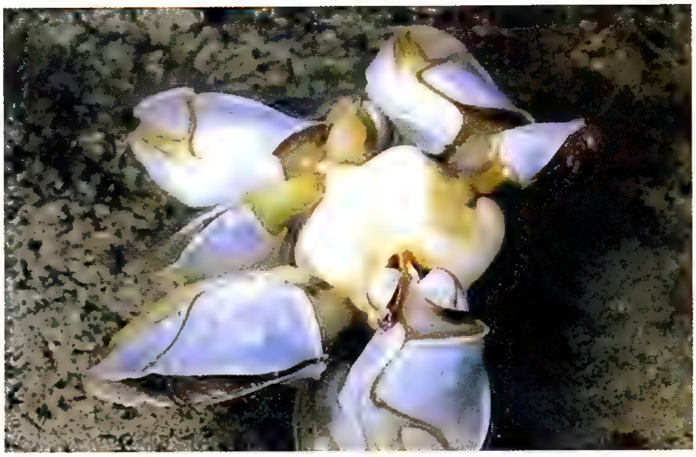
Not all the Sahara is sandy, but wherever wind-blown sand settles for any reason, more is likely to collect in the same place. Sand accordingly forms wind-driven dunes, whose behaviour is astonishingly complex. Surface sand seldom piles higher than a couple of hundred metres above underlying earth or bedrock, except by filling ancient valleys or lakes. Such deep sands and spongy sandstone form important groundwater reservoirs. And yes, sand does form and re-form constantly as water erosion, frost and wind-driven particles flake grains off rocks. Conversely, deep moist layers of sand become cemented into sandstone, which in turn may go through the same cycle after millions of years.

Far deeper sand occurs in submarine detritus fans which build up at the mouths of rivers. Even more intriguingly, the Mediterranean has dried up repeatedly in the last tens of millions of years. Each time that happened, rivers flowing into the basin eroded their fans into massive canyons, which silted up again whenever the sea returned. The bed of the lower reaches of the Nile consists of silt, more or less compacted, kilometres deep, turning it into an underworld canyon that has dwarfed the Grand Canyon in the past.

Jon Richfield
Somerset West, South Africa

At more than 9 million square kilometres, the Sahara is the world's largest desert but it has no uniform topography. About 15 per cent of the area is covered by sand dunes, 70 per cent is made up of stone deserts of denuded rock and coarse gravel, while the rest is oases and mountain ranges. Beneath the sand dunes lies rock of varying types. In Algeria and Libya, deposits of oil and gas have also been discovered, although inaccessibility has hampered their exploitation. The same forces that remove sand from the Sahara are also largely responsible for it being replenished. The wind not only sweeps sand from one area, but causes erosion of rocks in others which leads to it being replaced.

Ian Smith
London, UK



THIS WEEK'S QUESTIONS

Beach life

On holiday on the Dingle peninsula, south-west Ireland, this summer I spotted a sea creature I had never seen before. There were large numbers of them on the beach. I showed my photograph (above) to a boatman and he thought maybe they were related to the goose barnacle. Can any reader offer a positive identification and a description of the creature's life cycle?

Girish Patel
Wirral, Merseyside, UK

Wakey wakey

Why is it when we are tired the blood vessels in our eyes are more visible?

Lucy Bennett
By email, no address supplied

Bovine challenge

How long would it take an average cow to fill the Grand Canyon with milk?

Nicola Stanley
Cambridge, UK

Loud shirt

I recently appeared on my local TV station. When I arrived at the studio I was asked to change my shirt because its pattern would look distorted on screen. What causes this effect and why, in this day and age, is it impossible for television to simply record what is in front of the cameras?

Alan Francis
Cardiff, UK

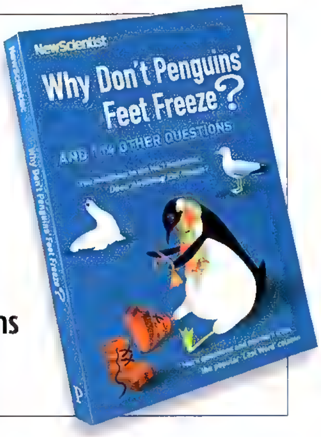
Questions and answers should be kept as concise as possible. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and a fax if you have one. Questions should be restricted to scientific enquiries about everyday phenomena. The writers of all answers that are published will receive a cheque for £25 (or the US$ equivalent). Reed Business Information Ltd reserves all rights to reuse question and answer material submitted by readers in any medium or format.

Send questions and answers to The Last Word, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, UK (fax +44 (0) 20 7611 1280) or by email to lastword@newscientist.com (all correspondents should include their postal address in order to receive payment for answers). If you would like a complete list of all unanswered questions please send an SAE to LWQlist at the above address.

Memorable answer? As part of our 50th anniversary we have teamed up with Crucial Technology (**www.crucial.com/uk**) and will be awarding each successful author a 512MB Gizmo! overdrive.

WHY DON'T PENGUINS' FEET FREEZE?

The latest collection from The Last Word, answering some of the world's most baffling questions



Feedback

PAUL MCDEVITT

THE camera on board the Mars Reconnaissance Orbiter is fulfilling its promise. At the end of last year the SpaceDaily website reported that the camera would be able to "see things on the planet as small as a dishwasher" (12 November 2005), and *Sky and Space* magazine declared that "while previous cameras on other Mars orbiters could identify objects no smaller than a school bus, this camera will be able to see something as small as a dinner table" (3 December 2005).

Now, as several readers have noted, a press release from NASA informs us that "rocks and objects as small as armchairs are revealed in the first image from NASA's Mars Reconnaissance Orbiter since the spacecraft manoeuvred into its final, low-altitude orbital path".

What all this terrestrial domestic detritus is doing on the planet remains unexplained.

SOMETHING feels not quite right about the way the UK's Institute of Scientific and Technical Communicators describes its attempt to encourage input from its members. A section of the ISTC's website is devoted to its annual conference, held earlier this month. This includes a page headed "Brainstorm", which announces: "There will be a brainstorming session held immediately before the AGM... No discussion of ideas will be permitted."

According to the Irish edition of *The Sunday Times*, Graham Johnston informs us, "An average Irish person creates 137 stones (869 kilograms) of rubbish a year, equivalent to the weight of a basking shark." So now you know

RECALLING our excursion into bananana-land on a famous web search engine (2 April 2005) Angi Mauranen found himself investigating grandfathers on the same FWSE. He ran a search on great-grandfather, great-great-grandfather, great-great-great-grandfather and so on, and found, interestingly (he thought), that after an initial decline in the number of hits every time he added another "great", the number suddenly curved up again until it reached a steady phase of around 14,000 hits, where it stayed until 31 "greats". At this point the FWSE announced that it limits searches to 32 words (one of which in this case was "grandfather") and would go no further.

Mauranen found that the FWSE behaved the same way when he looked for grandmothers, but says, in a sudden outbreak of sanity, that readers will have to do the job themselves for grandsons and granddaughters.

WHEN Barbara MacArthur left Cardiff Royal Infirmary in the UK with her son after his eye test, they took a wrong turn and found themselves at the back of the hospital where the bags of rubbish were taken. They saw a large notice on the wall and decided to take the advice it gave, which was: "Refuse to be put into the Incinerator."

ON the problem of reforming the German healthcare system, Wolfgang Böhmer, leader of the government of Saxony-Anhalt, has this to say: "I can't see the quantum leap. But even if we proceed in smaller steps this would be a success." The statement has left us trying to think of a step that is smaller than a quantum leap. So far we haven't succeeded.

FROM Scotland, Mark Stevens tells us that while walking through Waverley station in Edinburgh he heard an announcement from the station's automated announcement system, which puts fragments of speech together to form the message. These, he says, never sound natural due to the pause that is inserted between each of the fragments, making even straightforward messages sound incomprehensible. What he heard that day went something like this: "The train at platform... 1... is the... 08.25... service to... Brunstane. Calling at... Brunstane... and... Brunstane. This train will terminate at... Brunstane. For stations beyond... Brunstane... please change at... Brunstane." Got that?

FROM our Department of Redundancy files comes this press release put out by the Burson-Marsteller PR agency on 27 June: "Today, the leading peer-reviewed oncology publication, *Cancer*, published by the American Cancer Society, released a study that examines the fear and uncertainty that comes with a prostate cancer diagnosis – particularly among men."

SEVERAL perplexed readers have told us about the instructions that come with a tube of Cetrimide antiseptic ointment. These say: "Usage – Cetrimide Cream is a mild antiseptic used to treat minor burns... Avoid contact with eyes, middle ear, brain and surrounding membranes." None of our readers can decide under what circumstances they would be likely to apply the ointment to their brains – and to be frank we can't either.

FINALLY, Ed Hutchinson has sent us a photo of a sign from a campsite encountered by his girlfriend in Scotland. It says: "Any dog fouling to be lifted or scooped into the undergrowth." Hutchinson comments: "Harsh, perhaps, but it's the only language they understand."

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

NewScientist

New Scientist Special Report
28th October 2006

Australian Biotechnology is taking off

New Scientist's the insider researches the best Australia has to offer the world - 28th October 2006

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The word

MARTIN PARR/MAGNUM

Copyright trap

THE Steinlaus – "stone louse" in English – is a rodent-like mite. According to the German medical dictionary *Pschyrembel*, it can be used to break down bladder, gall bladder and kidney stones. Research into its uses has progressed rapidly since it was first listed in 1983, and homeopaths have adopted it as a remedy.

Hang on a minute. A rodent-like mite? Sound unlikely? That's because the Steinlaus doesn't exist.

Why would the compilers of a dictionary deliberately include a false entry? The Steinlaus may be an in-joke, but it also serves the function of protecting copyright. Dictionary editors face a problem protecting their work. They invest hugely in compiling lists of facts, which are then easily copied, especially from digital editions. Copyright does not apply to facts, only to the way they are expressed or assembled, and a fictitious entry is the perfect way to detect large-scale unauthorised copying of such a collection. If it turns up in someone else's dictionary, that's strong evidence of plagiarism.

Many dictionary compilers use copyright traps. The *New Oxford American Dictionary*, for example, defines "esquivalience" as "the wilful avoidance of one's official responsibilities". In 2005 the editors confessed that they added it purely as a copyright trap. The word is deliberately badly formed because they were "trying to make a word that could not arise in nature". But ploughing through to result 112 of 51,800 Google search hits turned up the phrase "esquivalience in the Oval Office". Even if used for comedic effect, such an expression is likely to result in the word escaping into the wild.

> "A fictitious entry is the perfect way to detect plagiarism"

Is it only dictionary compilers who use copyright traps? Computer security people have an equivalent that they call a "honeytoken". To detect the theft of a mailing list, for example, you create a false entry and do not reveal it anywhere else. You could use the name Jakob Maria Mierscheid, a fictitious Social Democrat representing the real town of Morbach in the German parliament, which has listed him in its official directory since 1979. Naturally, he now has a blog.

Map-makers also use copyright traps. In the 1930s, US map-maker General Drafting Company marked the fictitious settlement of Agloe at the intersection of two dirt tracks on its Esso maps of the Catskill Mountains in New York state. Years later Agloe turned up on a map from rivals Rand McNally. Gotcha? Actually, no. Rand McNally managed to prove that the county administration had supplied them with the name. Apparently, reports map collector Ian Byrne from Milton Keynes, UK, "someone built a general store at the intersection and called it Agloe because that's what it was marked as on the Esso map". The fictitious entry had autoreified. In case you were thinking of copying this article, don't. You might fall into our own copyright trap. ●

Enigma

World Series

No. 1414 Richard England

BASEBALL'S so-called World Series is won by the first of the two teams involved to win four matches. Since matches cannot be tied, that means that it may be decided in 4, 5, 6 or 7 matches. Matches 1 and 2 are held on Team A's ground, matches 3, 4 and (if required) 5 on Team B's ground, and (if required) matches 6 and 7 on Team A's ground.

1. Assume that each team has an equal chance of winning each match and tell me what, as a percentage expressed to as many decimal places as are necessary, is the probability that: (a) the same number of matches will be played on each ground; (b) match 7 will be played.

2. Now assume that there is a 60 per cent probability that any match will be won by the home team and answer questions (a) and (b) as above.

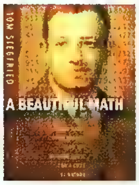
£15 will be awarded to the sender of the first correct answer opened on Wednesday 22 November. The Editor's decision is final. Please send entries to Enigma 1414, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address). The winner of Enigma 1408 is E. S. Grainger of Chelmsford, Essex, UK.

Answer to 1408 Consecutive digits
(a) 12345 (b) 87456

Bookends

Mind games

A Beautiful Math: John Nash, game theory, and the modern quest for a code of nature
by Tom Siegfried, Joseph Henry Press, ISBN 0309101921
Reviewed by Ben Longstaff



I SAW the film *A Beautiful Mind* on an aeroplane, dubbed into German with subtitles in Spanish. Though I struggled to make sense of it, it was clear this wasn't a detailed exposition of the mathematical output of its hero, John Nash. If you too hankered for more depth, treat yourself to this book. Siegfried paints a far truer picture of Nash's troubled life, and also gets stuck into his amazing contribution to game theory. After all if ducks can do game theory (read the book to find out why), you've no excuse not to give it a go.

Earth through a lens

Life: A journey through time
by Frans Lanting, Taschen, ISBN 3822839949
Reviewed by Adam Goff

FRANS LANTING is arguably the greatest nature photographer of recent times. The inspiration for his latest book came from photographing the ancient ritual of spawning horseshoe crabs. This led him to ponder the possibility of telling the story of life on Earth "from the earliest beginnings to the present through a selective interpretation of characters which tell a wider tale". It has been a mammoth undertaking, shot from the air, underwater and on the surface in every part of the planet, and has resulted in a stunning collection of photographs.

or more on the **Walter Rothschild Zoological Museum** at Tring in Hertfordshire visit **www.nhm.ac.uk/visit-us/tring**

So proud, peke owner Ivy Lord shows off the silver she picked up for her pooch at Cruft's dog show in 1924

modern civilization may be unaware of this, but the proud little Pekingese never forgets." Even today, the American Kennel Club says the dogs show "a combination of regal dignity, intelligence and self-importance", while the UK Kennel Club describes them as "small, well-balanced, thick-set with great dignity and quality…fearless, loyal and aloof."

At London's Natural History Museum, with eugenic ideas in the air, issues of pedigree and breeding were seen as topical. The director Ray Lankester decided to devote a wing of the museum to an exhibition of domesticated animals. It was opened in 1912 with the enthusiastic help of Richard Lydekker, a palaeontologist and wealthy country gent who contributed to *The Field* magazine. Lydekker knew many Pekinese-owning ladies and soon Ah Cum was not alone: 10 more donations swelled the ranks of stuffed pekes.

For all the concern with pedigree, the museum specimens vary noticeably in size, colour and carriage. The Honorable Mrs Lancelot Carnegie's Li Tzu even had atypical "butterfly ears". Aware that the popularity of the peke had led to further imports and breeding for quantity rather than quality, a breakaway group of aristocratic breeders formed their own exclusive society which met at the Ritz hotel in London. Desperate to maintain the supposed purity of the bloodline, they sought a model of the "original Chinese type" as depicted in ancient Chinese art, particularly images of the sacred Buddhist lion, from which according to legend the peke was descended. A few sceptics regarded such pursuits as "romantic nonsense" but they were in the minority.

Soon even the dogs remaining in China were deemed too coarse and common to count as pekes, particularly since the nation had become a republic in 1911. Only the "canine remnants of the old court jealously guarded by Europeans" counted as true Pekinese, says Cheang. As living imperial heirlooms and "high-born" animals, they affirmed the social status of their mistresses. Even the nouveau riche could move more easily into the upper echelons of society with a peke in their arms.

But for the magic to work, says Cheang, the purity of the line needed constantly to be guarded and traced back to the imperial court. That this lineage was more myth than reality has recently been exposed by a band of molecular geneticists in the US. As a spin-off from the dog genome project – which last year sequenced the genes of a boxer called Tasha – the geneticists compared a series of genetic markers in 85 breeds of domestic dog.

Mrs Murray and her friends would have been shocked to learn that their beloved peke was not as unique as they imagined. The Pekinese turns out to be genetically very similar to the Lhasa apso and shih-tzu, so much so that the investigators conclude they must all have come from much the same stock. There are signs too of extensive gene flow between the breeds.

And there's more bad news for the peke fan club. While the aristocratic ladies might have taken comfort from the knowledge that the peke is among the most ancient of breeds, they would almost certainly have blanched on learning that it shares that distinction with a motley band of 13 other breeds, including the Afghan from the Middle East, the Siberian husky, and the African basenji. Dissimilar though they are, these dogs do stand apart from other dogs in one respect, though Mrs Murray would probably not approve of the distinction. Of all dogs, they are the most closely related to the wolf. **Gail Vines** ●

Further reading: "Women, pets, and imperialism: the British Pekingese dog and nostalgia for Old China," by Sarah Cheang, *Journal of British Studies*, vol 45, p 359

Passionate about pekes

NATIONAL HISTORY MUSEUM

The death of a Pekinese dog on New Year's Day 1905 saddened all of London's high society. Pekes were the latest thing, fashionable yet hard to acquire – and Mrs Douglas Murray's prized red peke Ah Cum was top of the tree. Smuggled out of China in 1896 by her husband, who cited the feat in his entry in *Who's Who*, Ah Cum was regarded as a patriarch of the breed. Conscious of the momentous nature of his passing, Mrs Murray donated him to the Natural History Museum, where he was stuffed and displayed. There he remained for half a century. Today he is a prized specimen in the collection of domestic dogs at the museum's outpost at Tring in Hertfordshire. But why this passion for pekes?

AMONG all the world's breeds of dog – some 400 at the last count – the Pekinese held a strange allure for the fashionable set of Edwardian London. In less than a decade the peke had gone from being "a very rare and curious import" to "the breed of choice for smart British women", says Sarah Cheang of the London College of Fashion in a recent issue of *Journal of British Studies*. Almost every week, the society magazine *Ladies' Field* published photographs of elegant ladies posing with their pekes. One grandee even held a "Pekingese Spaniel 'At Home'" that was attended by all the best pekes in the capital. The dogs, tethered on the lawn, were admired by the Chinese ambassador as tea was served.

By 1914 the Pekinese was the most popular breed of pedigree toy dog in Britain, a position it defended for five decades. What fuelled this obsession with such a patently peculiar pooch? Cheang's investigations into the early 20th-century craze for all things Chinese suggest it was an intoxicating blend of genetics, racial mythology and western colonialism. Widely believed to have been bred within the secret enclaves of Chinese palaces, the dogs became a sort of living souvenir of Old China – "the mystical, impenetrable, and incomprehensible China of emperors and mandarins" – just as it was being swept away by western invasion.

The Pekinese first arrived in 1860 at the end of the opium wars, so-called because Britain had set out to force opium grown in its Bengal colony onto the Chinese market in the name of free trade. In the end, China was defeated and obliged to sign treaties with Britain, France, the US and Russia, granting them trading rights and semi-colonial powers over coastal ports.

The damage to the Chinese imperial state was substantial. In 1860, troops even plundered the emperor's Summer Palace outside Peking and then burnt it to the ground. Most accounts agree that during the looting, five Pekinese were found abandoned in the royal apartments of a Chinese empress. Appropriated by the British top brass, the dogs were shipped back home as trophies of war. The Duchess of Richmond and the Duchess of Wellington had four of the dogs between them, while the fifth, a fawn-and-white bitch shamelessly named Looty, was presented to Queen Victoria, who commissioned her portrait. The painting was exhibited at the Royal Academy in London and then hung in Windsor Castle.

> "Owning a Pekinese trumped any amount of fine porcelain"

Already the dogs had become symbols of western superiority and mementos of empire. Cheang argues that central to their appeal was their link to the defeated imperial Chinese court. When fresh breeding stock was imported during the 1880s and 1890s, all the animals were said to have been obtained illicitly from corrupt palace eunuchs, including the legendary Ah Cum, who was donated on his death to the Natural History Museum. Everyone wanted to believe that real pekes belonged exclusively to the closed world behind the imperial palace walls. "The plain truth is they have to be stolen, and it often takes months before a favourable opportunity offers," confessed the *Ladies' Field* in 1901. China was in the headlines again in the wake of the Boxer Uprising, a popular rebellion against the foreign invaders that was brutally suppressed by British forces. Imperial China was rapidly becoming a thing of the past.

Meanwhile, in upper-class London circles, "nostalgia for Old China" had reached its peak, and chinoiserie was all the rage. Owning a Pekinese trumped any amount of fine porcelain, for it meant owning a mysterious and alluringly exotic animal that retained a race memory of its imperial past. With the science of genetics already part of popular consciousness, peke owners detected signs of aristocratic Chinese behaviour in their charges. Some owners even claimed their dogs preferred yellow, the sacred colour of the Chinese emperor, and were frightened of thunderstorms because they retained innate memories of tropical typhoons.

A history of the breed published in 1931 stressed the peke's special qualities: "How many people realize, as they walk abroad with that most uncannily clever four-footed friend, that they are in the company of one of an imperial race of the loftiest lineage, a race that for hundreds of years was never set eyes on by any but the most privileged persons of the royal court, a race that less than a hundred years ago was shrouded in mystery... We of a

In our post-industrial knowledge economy, schools and grades are what really count

intelligence, such as cognition, reasoning, inference and learning.

The lay concept of "intelligence" is of a kind of substance, of "stuff", that different people have in different degrees, like cholesterol or blood sugar. By contrast, the scientific concept of "cognition" involves complex interactions between many varied computational and neurological mechanisms with long developmental histories. Ultimately, these complex interactions allow people to make their way in the world. The popular concept of "intelligence" is much like the popular biological concepts of "energy" or "vitality": it sees a complicated set of functional relations as a single force.

Most developmental and cognitive psychologists simply don't talk about intelligence at all, singular or plural. They talk, rather, about "intuitive systems" of knowledge, such as "folk" theories of psychology or physics or number systems or grammars that allow us to make both predictions and generalisations. Or they talk about computational capacities such as causal inference, or statistical induction, that enable us to learn these intuitive systems. However, none of these mechanisms divides neatly into "types" of intelligence.

Goleman and Gardner recognise this divide between intuitive and scientific ideas. In fact, it was clearly the motivation for Gardner's original work. And yet, as Gardner himself sometimes ruefully remarks, the very success of the "multiple intelligences" idea suggests that the audience really doesn't get it. Rather than seeing that intelligence isn't a substance at all, people now seem to think it is several substances – social, emotional and logico-mathematical.

So what makes the idea of intelligence so captivating when it has such little scientific warranty? I think it may have more to do with what I call "baboonery" (the systems of status, hierarchy and dominance we share with primates) than with cognition. In human societies, status is related to objective sources of power: land in a feudal society, wealth in an industrial one. But people often seem driven to explain status in terms of mysterious extra substances that the elite have and the plebs don't: "nobility" and "gentlemanliness" instead of inheritance, or "entrepreneurial spirit" and "hard work" instead of cash.

> "The lay concept of intelligence is of a substance, of 'stuff' "

In our post-industrial knowledge economy, schools and grades are what really count. "Intelligence" is our "nobility", the magic stuff that gets us to the top and keeps us there. However mysterious it may be, at least everyone agrees that it helps you do well at school. No modern parent would ever say "my kid may not be that bright, but he works hard", as their industrial immigrant forebears might have done. Instead, our universal complaint that "he's really smart but he just won't apply himself" is a disguised boast. Bill Clinton's Rhodes scholarship erased his poor Arkansas upbringing and made him part of the elite, while George W. Bush's flamboyant stupidity cancels out his rich Connecticut childhood and makes him a regular guy.

No wonder people are glad to hear that there's more intelligence around than they thought. Talking about "emotional intelligence" or "social intelligence" is like talking about "the nobility of labour" or "being a natural gentleman". It's a way to soften the brutal realities of an arbitrary scholastic pecking order. This is a more attractive and humane picture of intelligence than the genetic scarcity picture painted in *The Bell Curve*, but it may be just as removed from what Goleman and Gardner intended. ●

Social Intelligence
by Daniel Goleman, Hutchinson, ISBN 0091799430

Multiple Intelligences
by Howard Gardner, Perseus, ISBN 0465047688

Alison Gopnik is a cognitive psychologist and science writer. She is co-author of *How Babies Think*

WHAT'S INTELLIGENCE GOT TO DO WITH IT?

Once upon a time you were just plain smart: now there seem to be many kinds of intelligence on offer. Are we losing the plot, asks **Alison Gopnik**

POPULAR science writers face a dilemma. Laypeople come to science with their own systematic ideas about how the world works – ideas often far removed from scientific ones. To explain science effectively, we need to start from these everyday intuitions and move readers towards the scientific concepts. Yet we often end up simply reinforcing the initial intuitions rather than overturning them. No matter how carefully we report and interpret, the reader's final picture will often be quite different from the one we set out to paint.

I'm no exception. I write: "Science shows that babies are brilliant learners," and readers think: "If I buy the latest educational gizmo for my one-year-old, he'll go to Harvard." Popular science may even create fabulous intellectual monsters: chimeras of scientific and everyday ideas that take on a life of their own. One example is the way research on the lateralisation of brain function has been hugely oversimplified into the idea that right and left brain control different skills.

Of course, this may not always matter much: colourful metaphors in physics or cosmology can give readers a feel for otherwise extraordinarily difficult concepts. The real problem arises when it comes to the human sciences of biology, psychology or neurology. Everyone has beliefs about human nature, and often those beliefs have deep social and political roots and implications. Scientific psychologists need both to engage with those beliefs and revise them.

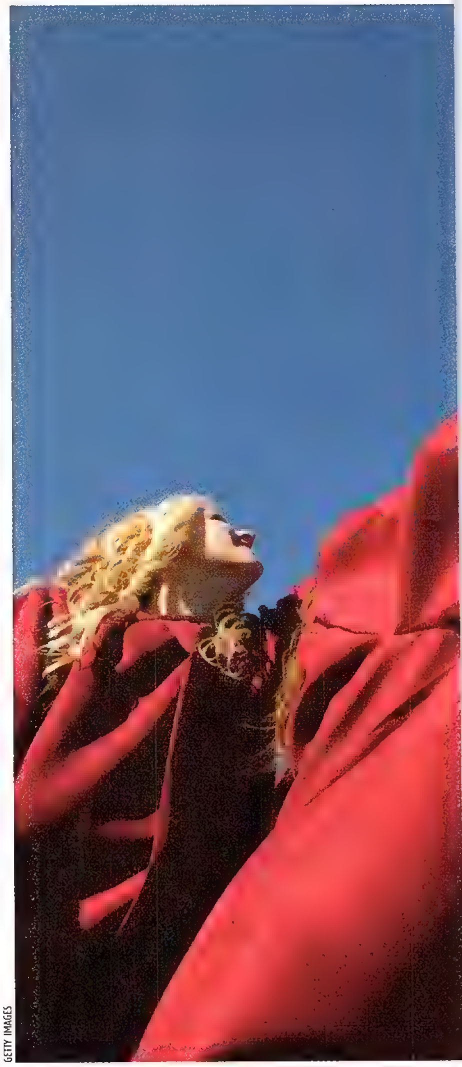
All of the above is a preamble to thinking about two new books that exemplify the science writer's dilemma: Daniel Goleman's *Social Intelligence* and Howard Gardner's *Multiple Intelligences*. Both authors have already written best-sellers proposing new kinds of intelligence ("emotional intelligence" in the case of science writer Goleman, and "kinaesthetic, musical and interpersonal intelligence", among others, in the case of Gardner, who is a distinguished Harvard educator). Their latest books may well become as popular as the earlier ones, but for me they are simultaneously attractive and troubling because they come to challenge popular intuitions about "intelligence" but may end up reinforcing them.

The attractions first. Both writers are effective popularisers of science, and both books are clear, informative and readable in different ways. Goleman's is anecdotal and journalistic, covering a very wide range of research, while Gardner is elegant and magisterial about his own earlier research.

Goleman's book is a rich compendium of recent developments in developmental and social psychology and the burgeoning field of social neuroscience. Psychologists have discovered that humans have particularly sophisticated skills to help us understand each other. One prominent evolutionary speculation proposes that it was the ability to understand other people that fuelled human cognitive evolution. More recently, neuroscience has confirmed that extensive and specialised brain circuitry is indeed devoted to understanding others.

That aside, neuroscience often tells us little more than we already know. We knew that the seat of emotion was somewhere above the neck and between the ears; now we know that it is closer to the bottom of the skull than the top. Still, there is a great deal in Goleman's book to interest and inform the general reader who may still think Freud is the last word on the science of human relationships.

Gardner's book, on the other hand, updates his earlier ideas on multiple intelligences, and charts the positive impact these ideas have had on educational practice: more emphasis on meeting the needs of the individual, focusing on a few topics in depth, and cultivating learning and thinking rather than the mere answering of standardised questions. At a time when such ideas are under severe political attack, Gardner's eloquent re-articulation and defence of them is especially welcome.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Now for the troublesome bit – and the dilemma. What's intelligence got to do with it? The runaway success of Gardner's and Goleman's earlier books parallels the notoriety of Charles Murray and Richard Hernstein's *The Bell Curve*, in which they argued that racial inequalities were due to genetic differences in intelligence. There seems to be a popular fascination, not to say obsession, with the idea of intelligence. But outside of a narrow subfield within psychometrics, "intelligence" simply doesn't play a role in current scientific views of the mind. Not one of my 40 colleagues at the University of California, Berkeley, would say they study intelligence, which is particularly striking since most would agree that they study topics that seem closely related to

that research, in 2001, I predicted that annual revenues in virtual worlds would top $1.5 billion by 2004.

Today it must be even bigger, mustn't it?
I haven't repeated the study. It got reported as "an economist says that a fantasy economy is bigger than the economy of Bulgaria", which it isn't. So I have shied away from that number. What I've done since then is to track the health of the virtual economies, keeping an eye on exchange rates and currencies. For example, today you can buy a gold piece to use in World of Warcraft for 9 cents. I have seen auctions for $10,000 for a set of player accounts to use in Everquest, but I don't know if they sold. I spent $500 myself for an account, just to see if it was real. It was.

Why do people pay hard cash for fantasy items?
In the fantasy world, if you own a horse you go faster: this makes for a better game, and you can travel more easily to see your friends in another location, just like you do in the real world. It's also about reputation and prestige – "my horse is bigger than yours". But when you start out in the virtual world, you start with nothing and it's hard work to build up capital. That's why people are prepared to pay real dollars for virtual items.

Have you ever sold anything that you've built up in online games?
No – I've made virtual money but not real money. I'm not that good a gamer and I'm also in two minds about it. As an economist I understand why this trading happens but as a gamer and someone interested in human culture I think it's deplorable that people use real money to get ahead in a game. I hate that. One of the fundamental design features of these games is that everybody starts out with nothing. The idea of a world of equal economic opportunity is a long-standing human dream. And it exists, right there, if only these jerks would stop spending real money to get ahead.

> "It's deplorable that people use real money to get ahead in a game"

Exploring the synthetic worlds that games offer has made a real-world difference to Edward Castronova

Do you think it was you that put these virtual worlds on the map?
When I published my economic analysis of this "Cyberian frontier" in 2001, I told the readers that I felt like an explorer and that I'd just discovered a new world. And I do feel like Captain Cook, to some extent. If you told me in 1995, when I was working on the welfare state, that I was going to become a video games scholar, I would have leapt for joy but not believed you. But the subject suddenly became salient at the same time as I was writing about it. That, combined with the conservatism of most researchers in the social sciences, left a huge chunk of academic activity open for me to explore.

How was your research viewed by other economists when you started working on virtual worlds?
My first efforts to publish papers about this in normal economic journals were turned down. They weren't convinced that virtual reality mattered at all.

Should virtual worlds be policed, like the real world is?
It's a dilemma. Within a game, if I trick you into giving me your goods, that's one thing. But if I hack into the server, then that's considered a crime. A big percentage of computer crime in Korea is people hacking into online games and switching ownership of items. If they could claim they were acting within the rules of the game, then the law gets really weird. I think it's going to take an explicit statement on the part of real-world governments to wall these places off and surround them with rules and regulations. The responsible thing to do is to seal off that economy from the real economy. Otherwise people will increasingly use these spaces for commercial activity, even crime, instead of the pure fantasy for which they are intended.

Do you think politicians will have to find ways of dealing with this?
There have already been court cases in Korea and China on these issues. Suppose there's a breakdown in the server, and somebody logs in one day and all their equipment in the game is gone. They complain to the company, which says that they have to start over again. That would cost someone a lot of money and they could sue. Could a government emerge within those spaces to address these issues? Maybe. If it did would it be another nation state? That's the brave new world that I can't get my mind around. ●

Photography: Chris Meyer

Striking out for the new territory

Edward Castronova has got to be the only person in the world to rescue a failing career by calculating the gross domestic product of a place that doesn't exist. Just four years ago he was teaching at a college that didn't grant PhDs, no one knew his research, and his wife lived out of town. Then one lonely night when Castronova was playing the online game Everquest, he noticed something that piqued his economist curiosity. Normally gamers derive status or virtual goodies through their skill; here were players with great status and wealth but no idea at all of how to play. It turned out they had paid real-world cash to buy virtual artefacts or characters. Castronova decided to put a rough figure on the economic activity of this synthetic world. It was startling: Everquest's GDP per capita nearly equalled Russia's. Almost overnight, Castronova became a leading authority on the implications of large-scale online games. He reckons that leakage from the real world makes virtual worlds ideal for testing economic or social theories. And, as he told **Alison George**, he is about to build his own game.

To be good for modelling economic or social theories, do these "synthetic worlds" you work on have to be big and complex?

They are. They involve massive multiplayer online role-playing games, in which a large number of players interact with each other in a virtual world. The biggest is World of Warcraft, which has 6.5 million users worldwide. The populations of these worlds are growing exponentially. Right now it looks as if the user numbers are growing according to Moore's law and doubling roughly every two years.

You've just received a $240,000 grant from the MacArthur Foundation to build your own game. What are you going to do with it?

I'm working on the idea of using virtual worlds as Petri dishes to conduct experiments about social-science issues. We're going to develop a fantasy world based on the plays of Shakespeare. I want to use it to test an economic theory called the quantity theory of money supply, which is about how the supply of money affects inflation – but this role will be invisible to the user of the game, who will be playing for fun. There will be two parallel worlds, which will be exactly the same except for the amount of money in them. So you will have two exactly equal virtual macro-economies in which you can vary one thing, something which is impossible to do in the real world. I think that's an unprecedented research opportunity.

What made you think you could manipulate virtual worlds to test economic theories?

I was playing games like Everquest, which is an online fantasy role-playing game a bit like Dungeons and Dragons, when I stumbled across this area of the game where there were hundreds of people collecting around torches, like an open-air bazaar, to buy and sell virtual items. I noticed how many players were prepared to pay real money to buy these virtual items, so I decided to write a paper about it. Instead of the World Bank report on Poland, for instance, it would be Castronova's report on Everquest. I would treat Everquest like a real country and try to collect all the standard macroeconomic statistics: GDP, inflation, productivity and wages. The more information I got, the bigger the economy of Everquest appeared to be.

What did you find?

I calculated that a single worker could make about $3.50 an hour, if the fruits of their labour were converted to real money. According to that measure, a citizen of Everquest could produce as much wealth as someone living in, say, Bulgaria, and four times as much as someone in China: this game world is small but hosts a lot of productive economic activity. At the time of

Profile

While studying for a degree in international affairs at Georgetown University, Washington DC, and a PhD in economics at the University of Wisconsin-Madison, Edward Castronova also spent much time honing his gaming skills. From 1991 to 2000 he was a associate professor at the University of Rochester, New York, focusing on welfare reform. His paper "Virtual worlds: a first-hand account of market and society on the Cyberian frontier" is one of the most downloaded papers on the Social Science Research Network. Castronova is now associate professor of telecommunications at Indiana University in Bloomington. The paperback edition of his book *Synthetic World* is published this month by the University of Chicago Press.

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Eggs unlimited?

Two years ago, Jonathan Tilly of Harvard Medical School set tongues wagging when he challenged the received wisdom that women are born with a finite supply of eggs. His studies suggested that the eggs in a female mouse do not last its lifetime, implying that it must create eggs after birth. The source, Tilly suggested later, are cells from the bone marrow. When he transplanted bone marrow cells into mice, he later found immature eggs derived from the transplanted cells in their ovaries.

This finding, if true, could lead to new fertility treatments. Yet in June this year, the idea seemed to be quashed. Amy Wagers's team, also at Harvard Medical School, linked the circulatory systems of two mice. Several months later, she looked to see if any eggs from one mouse derived from the cells of the other. None did. And unlike Tilly, Wagers focused on ovulated eggs. "This is the important pool of cells," she says, "because they are the only ones that contribute to fertility."

So are hopes of an inbuilt, unlimited source of eggs dead? Not entirely. Jeff Kerr's team at Monash University in Clayton, Australia, recently counted egg-containing primordial follicles in the ovaries of mice, from birth to early adulthood. To their surprise, the numbers did not decline with age. "If the dogma were true, you'd expect half of them to have disappeared," says Kerr. The jury is still out. Helen Pilcher

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sperm were poor swimmers and had to be injected into eggs. Of 210 eggs injected with ESC-derived sperm, only 65 began dividing, yielding seven live births after implantation. "The success rate is low," admits Nayernia. What's more, the mice, all of which died within five months, had health problems like those seen in cloned mammals. They were either too big or too small, and suffered from breathing problems and tumours.

This is probably due to the biggest challenge facing those trying to grow sperm or eggs: imprinting. In different cell types in the body, various sets of genes are switched on or off by adding chemical tags to DNA. During the development of sperm and eggs, the existing tags have to be stripped away and new ones added. Certain genes must be switched on in maternal chromosomes but switched off in paternal chromosomes, and vice versa. Any disruption of this imprinting process results either in the embryo's death or in serious abnormalities.

"Imprinting is always likely to be a problem for lab-grown eggs and sperm," says Harry Moore of Sheffield University, UK, whose team has managed to coax human ESCs to turn into early sperm that appear to have undergone meiosis. Imprinting is thought to be controlled by a complex mix of external signals and internal processes. "But we just don't know what these signals are."

Once the process is fully understood, however, it might be possible to fine-tune culture conditions and growth factors to ensure stem-cell-derived eggs and sperm bear the correct imprints. It should also become feasible to screen embryos to check that they have the correct imprinting, which would greatly improve safety.

"Will lesbians ever be able to have their own children? I think it could be done in time"

That leaves another huge problem: even if researchers succeed in growing sex cells from human ESCs, there is as yet no way to create ESCs that carry the genes of would-be mothers or fathers. Therapeutic cloning – injecting adult DNA into an egg with no nucleus to create an embryo from which ESCs with the adult DNA can be derived – has yet to be achieved in humans.

Another possibility is a technique called haploidisation: if an adult nucleus with two sets of chromosomes is injected into an egg that has had its genetic material removed, the cell can be stimulated to spit out one set to produce an egg with the normal number (*New Scientist*, 7 July 2001, p 5). Incorrect imprinting prevents these eggs from developing far when fertilised, however.

The ideal solution would be to persuade adult cells taken from would-be parents to turn into eggs or sperm. This has yet to be achieved but some have come close. Earlier this year Julang Li's team at the University of Guelph, Ontario, managed to produce egg-like cells from stem cells isolated from fetal pig skin, for instance, and Nayernia's group has persuaded adult bone marrow stem cells taken from mice to form cells that resemble immature sperm.

So while there's still much basic biology to be done, big advances have been made. Many in the field now think it is only a matter of time before the first child conceived with a lab-grown sperm or egg is born. And the applications needn't stop with treatments for infertility.

Male stem cells could be persuaded to yield both sperm and eggs, so in the future two men would be able to have a son or daughter who is genetically their own. "It's all very well in theory," says Reijo Pera, "but there are still a lot of really big problems to overcome – like no uterus and no breasts!" Any embryo would have to be carried to term by a surrogate mother.

For two women, the situation is trickier still, because female cells lack the male Y chromosome, which carries the genes needed to make sperm. "If you want to make a functional sperm, you need a Y chromosome," says Robin Lovell-Badge of the National Institute for Medical Research in London, who studies sex determination. "So it's good to know that us men are still good for something."

Perhaps not essential, however. Two years ago, Tomohiro Kono from the Tokyo University of Agriculture and colleagues combined two eggs to create a mouse with two mums (*New Scientist*, 24 April 2004, p 8). This shows that the imprinting barrier can be overcome. But to mimic the effect of male imprints, the team had to genetically modify the mouse that provided one of the eggs. Clearly a different method would be needed for women. And the success rate was low: after more than 400 attempts only one mouse, named Kaguya, survived to adulthood. She has since had healthy offspring of her own, conceived in the normal way.

So will lesbians ever be able to have their own children? "It's a question I get asked quite a lot living in San Francisco," says Reijo Pera. "I think we're good at manipulating germ cells in the lab, but not outstanding. To translate this work to the clinic, we need to be outstanding. But I do think it could be done in time."

Yet while methods such as fusing two eggs could one day help two women to produce a daughter who is genetically their own, they could have not have a son. If we want to keep the male of the species around, we may have to keep them involved in the reproductive process for a little while longer. ●

Helen Pilcher is a freelance writer based in Nottinghamshire, UK

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"If you want to make sperm you need a Y chromosome. So us men are still good for something"

since created similar "eggs" from ESCs, none has developed far after fertilisation.

That is why Alan Trounson, who studies stem cells at Monash University in Melbourne, Australia, thinks most of the ESC-derived eggs produced so far have not completed meiosis. "Oocytes are very sensitive cells and it doesn't take much to send them off the rails," he says. "Getting them to mature and undergo meiosis is a big hurdle."

Providing the perfect environment may help to solve this problem. "If you get the niche right, meiosis should follow," says Renee Reijo Pera from the University of California, San Francisco, who studies sex cell development.

One way to achieve this may be to provide the right growth factors. In unpublished studies, Reijo Pera has found that adding bone morphogenetic proteins, which influence embryonic development, to the growth media increases the number of egg and sperm precursors from around 0.1 to 5 per cent. Meanwhile, Trounson has found that the liquid in which testes cells have been grown pushes mouse ESCs to become follicle-like structures containing egg-like cells (many of the growth factors for sperm and egg development may be the same).

Neither Trounson's nor Reijo Pera's approach yields perfect cells, however. Teresa Woodruff of Northwestern University, Illinois, thinks part of the solution is to give developing follicles more physical support. She has injected intermediate-stage mouse follicles taken from ovaries into supportive gel capsules made from alginate, a seaweed derivative. The follicles develop beautifully and when ovulation-inducing hormones are added, fertile eggs pop out.

"We were just blown away by how good this system is," says Woodruff. She thinks the flexible gel sac gives follicles the space they need to expand while maintaining the essential connections between the egg and the surrounding cells. If the same can be achieved with intermediate-stage human follicles taken from ovaries, this would be a big step forward in itself, perhaps allowing many more eggs to be obtained than is possible with existing in vitro maturation techniques (see page 42).

Making the leap from mouse to human may not be easy with any of these approaches, however. For one thing, human eggs take longer to mature in the body than their lab-reared, ESC-derived counterparts. Yet if eggs do not receive the right signals in the right amounts at the right time, they may fail to mature properly.

While those trying to grow eggs tinker with their systems, efforts to derive sperm are forging ahead. Earlier this year, Karim Nayernia's team at the University of Newcastle upon Tyne, UK, hit the headlines when it became the first to achieve live births from mouse sperm grown from ESCs.

The team persuaded their stem cells to differentiate into both sperm and the Sertoli cells that support and nurture them. But the ▶

Too posh to get pregnant?

Could women one day have babies without getting pregnant – just as men do? Artificial wombs have long been a staple of science fiction, from Aldous Huxley's *Brave New World* to *The Matrix*. Now Hung-Ching Liu's team at Cornell University's Center for Reproductive Medicine and Infertility in New York City is making them a reality.

She has grown mouse embryos for 17 days – just two days short of full term – in an artificial womb made by growing uterine cells over a scaffold of connective tissue. So far, all the fetuses have been deformed, but when the wombs are implanted into female mice the fetuses develop without malformations, though they are much smaller than normal. "We believe it is possible to have a functional mouse womb in the next decade," Liu says.

Her aim is to help women whose uterus is diseased or damaged. Such women could have an artificial womb implanted – or it could theoretically be used outside the body. The team has already successfully grown human embryos in artificial wombs for 10 days, just short of the 14-day limit allowed for human embryo research in the US. However, regulatory and ethical restrictions may prevent human trials from ever taking place. Women who want a baby without the weight gain and stretch marks face a long, long wait. Jo Whelan

The egg and sperm race

From genetically engineered people to gay couples siring their own biological children, turning stem cells into sex cells could open up all sorts of possibilities. **Helen Pilcher** reports

D. PHILLIPS/SCIENCE PHOTO LIBRARY

IT WAS a cruel blow. At just 30 years of age, Jessica (not her real name) was told she had breast cancer. She survived, but the treatment that saved her life robbed her of her fertility, so she will never have the family she dreamed of starting.

Every year, hundreds of thousands of women undergo cancer treatments that can damage their ovaries. Only some can have eggs or ovarian tissue frozen.

Millions more women delay having children or do not get the opportunity until late in life, only to discover they are no longer fertile. In the future, freezing eggs while you are still young might enable you to avoid this predicament, but for now it is very expensive and the success rate is low (see "Methuselah moms", page 46).

Donated eggs are an option. But they are hard to come by, and most women would prefer to have a child that is genetically their own. In the not too distant future, however, there might be another solution. Egg and sperm-like cells have recently been derived from animal stem cells, and this year the first mice were born from lab-grown sperm. Many groups around the world are racing to produce fertile human eggs and sperm in a similar manner.

The technical and practical obstacles remain immense, but if these researchers succeed the implications go far beyond helping women and men who cannot produce eggs or sperm of their own. For starters, more eggs would mean more choice. A limitless supply of eggs could be used to produce hundreds of embryos for any one couple, making it feasible for would-be parents to use genetic screening to choose several desirable traits as well as ensuring embryos are free from disease-causing mutations (see "Sex is for fun, IVF is for children", page 42).

Should society ever choose to allow it, this new source of eggs and sperm would also make human genetic engineering practical: stem cell lines with the desired alteration could be created and sex cells derived from them. And to create healthy sperm or eggs in the lab, researchers will have to learn how to "reprogram" a cell's genome, as normally happens during the development of sex cells. If they succeed, this would also make it possible for gay couples to have children that are genetically their own.

Mimicking sex cell production is not easy. In mammals, sperm and eggs are produced in intricate, multi-stage processes that occur within specialised environments. The cells that give rise to eggs and sperm have to ditch one of their two sets of chromosomes during a type of cell division called meiosis. In men, new sperm are constantly produced, whereas women appear to have a finite supply of eggs (see "Eggs unlimited?", page 54), which start undergoing meiosis and form primordial follicles months before a girl is born.

Most primordial follicles remain in a resting state for decades but a continual stream of them resume development. The eggs they contain slowly grow to 200 times their original size and form a tough shell. Every month a handful of these pre-ovulatory follicles enter the final stage of development, but usually only one completes it. The egg finally finishes meiosis as the follicle swells to 20 millimetres and bursts open to release it. The process takes several months at least and is still very poorly understood.

Recreating it in a dish is tricky, to say the least. Yet in 2003, Hans Schöler, now at the Max Planck Institute of Molecular Biomedicine in Münster, Germany, triggered great excitement in the field by coaxing mouse embryonic stem cells (ESCs) in a dish to grow into egg-like cells. After a few weeks, some ESCs spontaneously formed large, organised structures that resembled follicles and released egg-like cells that showed signs of meiosis. But although other researchers have of you. If you have high blood pressure, are post-menopausal and want to get into a donor egg programme, you won't pass the screening test," points out Heffner. Many clinics simply turn away women older than 52, the average age of the menopause.

Paulson is generally upbeat about the prospects for over-50s. "We know women in their 50s who can handle a marathon, so they can handle a pregnancy," he says. "And having a pregnancy is worth some degree of risk." But he too stresses the importance of cardiovascular fitness.

Clearly, waiting until you retire to have children will not be a realistic option for most women any time soon. At the same time, the trend for women to have children later shows few signs of abating. "The women coming to see me are getting older and older. Maybe they don't understand their own reproductive physiology," says Rita Alesi, head counsellor at Monash IVF in Melbourne. "Or maybe they hear the media excitement about a woman in her fifties giving birth, and it makes them more aware of what is possible."

Of course, most people don't plan their lives with military precision. When you have children is often determined by chance events, such as meeting the right person or failing to use contraception. Nevertheless, is there a case to be made for governments to encourage women to have children earlier by, for example, a generous parental leave policy or free childcare?

While the health risks for older women and their children are higher, this needs to be seen in perspective: the risks are tiny compared with those facing young women in poor countries, and even in rich countries factors such as smoking during pregnancy may have a greater impact than maternal age. And some studies suggest that mature parents are better parents. "Some people leave it a bit late, but in general, delaying children until you are more mature socially, psychologically and economically, is a good thing," says Susan Harlap, who studies birth risks associated with older parents at the Mailman School of Public Health in New York. "Despite the increased risks, the vast majority of offspring born to older mothers are normal."

One worry is that children will be disadvantaged by ageing parents dying. But as Heffner points out: "We live a lot longer. If you are healthy, is there really any difference having a child today at 50 when you can expect to live into your eighties, to having child at 30 when life spans were only to the mid-fifties?" Nonetheless, she thinks that societies should put an age limit on motherhood.

> "Some leave it a bit late, but in general delaying children until you are more mature is a good thing"

Even if governments do try to intervene, it's not apparent if the trend for having children later could be reversed. The demand for new technologies looks unstoppable. As a sign of things to come, take Denmark. According to an unpublished projection by Tomáš Sobotka of the Vienna Institute of Demography , more than 6 per cent of all births to Danish women born in the 1970s will be a result of assisted reproduction.

The impact of egg freezing and PGD could be almost as revolutionary as the Pill, allowing women to routinely delay having their own children until they are well into their forties. Beyond this point, though, ageing bodies will limit what can be achieved. ●

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> "We know women in their fifties who can handle a marathon, so they can handle a pregnancy"

fresh eggs, it will become quite irresistible to many centres," he predicts. Some teams appear to be getting close, with one group in Japan claiming a success rate from frozen eggs nearly as high as that for fresh eggs at a conference earlier this year.

How irresistible it will be to women planning to delay children depends on how deep their pockets are. One private clinic in the US charges well over $10,000 to collect and store the eggs, just for the first year. Freezing eggs also means undergoing the pain and risks of egg collection: the hormones women have to inject can have serious side effects. New techniques that reduce or avoid the need for these hormones could soon make the procedure much safer, however (see "Sex is for fun, IVF is for children", page 42).

The combination of egg freezing and PGD promises to greatly increase older women's chances of getting pregnant and staying pregnant. Yet while the problem of ageing eggs looks solvable, the problem of ageing bodies is far harder to address.

There is some room for progress. Calculations by Heffner's team, for instance, suggest that in women over 35, weekly monitoring of the fetus from week 37, with induction of labour if necessary, could reduce the risk of stillbirth, saving the lives of 4 fetuses per 1000 pregnancies (*Obstetrics and Gynecology*, vol 104, p 56). Although this has yet to be proven, many obstetricians are already embracing the practice.

However, none of the fertility experts contacted by *New Scientist* is optimistic about the prospects of reducing older women's chances of developing pre-eclampsia. "Pregnancy is all about blood flow, including the blood vessels' ability to adapt to the 50 per cent increase in blood volume that occurs in pregnancy," says Paulson. Declining cardiovascular fitness may ultimately set the limit on the age at which women will be able attempt pregnancy. "If you have high blood pressure and you get pregnant, we'll take care

Adriana Iliescu sparked controversy when she gave birth at 66

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OFFICIAL FUEL CONSUMPTION FIGURES FOR SAAB 9-3 SPORTWAGON RANGE IN MPG (LITRES/100KM): URBAN 16.4 (17.2) - 39.2 (7.3), EXTRA URBAN 38.2 (7.4) - 62.8 (

IVF has already helped millions of women with fertility problems to have children. Yet as with natural conception, the success rates plummet for older women. One study found 28 per cent of women who started IVF at 40 ended up with a baby, compared with 10 per cent at 43 and none at all at 46.

One way around this is to use donor eggs from a younger woman. Donor eggs are in short supply, though, and do not help couples set on having their own genetic offspring. In the not-too-distant future it might become possible to generate eggs from other adult cells (see "The egg and sperm race", page 52). A more immediate prospect is for women to freeze their eggs when they are young.

"That will be really good news. If you haven't met anyone at 33, you could decide to freeze your eggs," says Heffner. With young eggs in the freezer, one of the biggest causes of the mismatch between an older woman's reproductive capabilities and her maternal desires would go out the window.

The first pregnancy involving a frozen egg was reported by an Australian team in 1986, yet while freezing embryos and sperm has become routine, freezing eggs has proved far trickier. The problem might be their large size and relatively impermeable shell and cell membrane, which means it takes a long time for cryoprotective chemicals that prevent the formation of damaging ice crystals to diffuse into the egg. Since these chemicals are toxic to the egg at body temperatures, the egg gets damaged during the very process that is intended to protect it.

Freezing and thawing can also damage the cellular machinery that ensures the egg ends up with the correct number of chromosomes. Studies in mice in the 1980s suggested that this could cause high levels of chromosomal abnormalities, leading to an unofficial moratorium on egg freezing.

But improvements in freezing methods have largely alleviated these fears, and there has been a resurgence of interest in freezing eggs, with private clinics already offering the procedure for a fee. Many groups worldwide are experimenting with methods that further reduce damage to the egg, such as vitrification, which involves cooling eggs so rapidly that the water becomes super viscous, forming a glass-like gel rather than ice crystals.

The published figures for the number of pregnancies from frozen eggs are disappointing – just 80 children born from 4300 frozen eggs. But the actual number of births is now closer to 500, says Michael Tucker of Georgia Reproductive Specialists in Atlanta. "We can improve on survival rates but nevertheless, the technology has come of age."

"A lot of people have been claiming great results," agrees Roger Gosden, director of reproductive biology at the Weill Medical College of Cornell University in New York. "The practice of egg freezing will grow steadily, matching the success rate of the technology. Once there is a breakthrough and someone manages to get a success rate that matches

> "The practice of egg freezing will grow steadily as the success rate of the technology improves"

How long have you got?

A few women can still conceive naturally in their fifties, while for others the menopause arrives unexpectedly before the age of 40, dashing their hopes of having their own biological children. For those trying to juggle a career with starting a family, it would clearly be helpful to find out when your biological clock is likely to strike midnight.

There are several tests that purport to measure a woman's "ovarian reserve", or how many eggs she has left. Methods include measuring the level of follicle stimulating hormone, as FSH levels start to rise a few years before the menopause, and monitoring the ovaries' response to fertility drugs.

Such tests, however, are more a measure of how many eggs a woman can produce now than how many fertile years she has left. A normal FSH level, for instance, doesn't tell you if you have 5 years left or 30, while if the level is high you may already have run out of time. So several groups are working on specific ways of predicting how many fertile years a woman has left, including measuring the different chemical forms of FSH and using an ultrasound scan to count the number of nearly mature follicles or measure the size of the ovaries. These approaches will provide only a rough estimate, though, and they cannot tell you if your eggs are healthy.

"We should be able to say, after a certain age you won't be able to conceive," says Thomas Kelsey of the University of St Andrews in the UK, who is evaluating the accuracy of measuring ovarian size. "But there is no guarantee that the eggs you produce up to that time can be fertilised." Michael Le Page

LANDMARKS IN REPRODUCTIVE TECHNOLOGY

1677	Anton van Leeuwenhoek sees sperm for the first time
1780	Lazzaro Spallanzani artificially inseminates dogs
1785	First confirmed human birth after artificial insemination, performed by Scottish surgeon John Hunter
1866	Paolo Mantegazza proposes freezing human sperm so soldiers killed in battle can still father heirs
1944	Human eggs reportedly fertilised outside the body. The claim is later questioned, but inspires other efforts
1953	First pregnancies achieved using frozen sperm
1954	An Illinois court rules that insemination with donor sperm is adultery
1960	The FDA approves the birth control pill
1974	First transgenic animals created
1977	Robert Edwards and Patrick Steptoe implant the embryo that will become Louise Brown, the first IVF baby
1982	The Sperm Bank of California makes donor semen available to unmarried women and lesbians
1983	First disease gene, for Huntington's, is located First pregnancy from a frozen embryo
1986	First pregnancy achieved with frozen eggs, but success rate remains low
1989	The first successful attempts at pre-implantation genetic diagnosis (PGD), leading to births in 1990
1992	First pregnancies achieved after intracytoplasmic sperm injection (ICSI)
1996	The first cloned mammal, Dolly the sheep, is born
1997	Cytoplasmic transfer results in the birth of a child with DNA from three adults
1999	New PGD methods can reveal chromosomal abnormalities
2000	First draft of human genome
2003	Egg-like cells derived from embryonic stem cells
2004	A mouse created by fusing two eggs is born
2005	A 66-year-old becomes the oldest woman on record to give birth thanks to donated sperm and eggs
2006	Mice created with lab-grown sperm are born

> "If you haven't met someone at 33, you could freeze your eggs. That would be really good news"

looking at larger studies, clear trends emerge.

Compared with 20 to 29 year olds, women who give birth over 40 are two to three times more likely to have a premature baby and/or a low-birthweight one (under 2.5 kilograms), with the risk increasing with age. And although many small babies will survive, the smallest ones often suffer a host of medical problems at birth, such as respiratory distress. The effects can last a lifetime: such children tend to have poorer academic records and lower IQs as adults.

The biggest worry for older mums is the huge increase in the risk of having a baby with chromosomal disorders. The most common is Down's syndrome, the risk of which increases from 1 in 1500 at 20 years old to 1 in 30 at 45.

Without the huge advances in medicine in the past century, however, the risks facing older mothers and their children would be far higher. For instance, there has been a fall in the number of children born with Down's syndrome despite the rising age of mothers, thanks to steady advances in prenatal screening in recent decades.

"Testing turns upside-down who's at risk," says David Nyberg, a radiologist in Scottsdale, Arizona, who helped run one trial of Down's screening. "The unaware 20-year-old who doesn't undergo screening ends up at higher risk than the aware 40-year-old who does and gets a good result."

Prenatal testing will undoubtedly improve further (see "A window on the womb", page 45), but an abnormal result will always leave prospective parents facing the heart-wrenching decision of whether to terminate the pregnancy. Women who undergo IVF, however, can avoid this dilemma, because pre-implantation genetic diagnosis (PGD) can now be used to screen out embryos with many chromosomal disorders.

Besides preventing disorders such as Down's, the hope is that advances in PGD will improve IVF birth rates, especially for older women, by distinguishing between healthy embryos and those doomed to fail. For the moment, though, the evidence is mixed (*New Scientist*, 28 May 2005, p 11).

Would-be dads beware

Men may not suffer the precipitous decline in fertility that women do, but there is increasing evidence that age matters for men as well. For starters, there is a steady decline in male fertility from age 20.

One study found that it takes 32 months on average for a 50-year-old to father a child compared with 6 months for a man under 20. Lifestyle factors such as bicycling, smoking and drugs such as cannabis and cocaine all make matters worse. Men over 35 are twice as likely to be infertile as those under 25.

The children of older dads are also more likely to have chromosomal disorders, though the risks do not rise as rapidly as they do for women: the risk of Down's syndrome for men over 50 is just four times as high compared with men aged 20 to 29. Older men are also more likely to father children with disorders such as autism, epilepsy or schizophrenia, possibly due to increasing numbers of spontaneous mutations as sperm form. "A man of 40 has the same risk of having a child with schizophrenia as a woman of 40 has of a child with Down syndrome," says research psychiatrist Dolores Malaspina of New York University. Older men's partners are also more likely to miscarry and to suffer pregnancy-related high blood pressure, called pre-eclampsia.

For these reasons most clinics only use sperm donors under 40. The overall risks for the children of older fathers, however, are low, and while freezing sperm is an easy and relatively cheap option for those worried about their future fertility, it is mainly used by men undergoing treatment for cancer. Rachel Nowak

STEPHEN CHIANG/WORKBOOK/JUPITER

How much time will technology buy women who want to put off having a baby? **Rachel Nowak** reports

AT FIFTY-FIVE years old, Angelina Calabro gave birth to her one and only child, a much-loved daughter called Carmelina. What sets Calabro apart from the handful of other women who give birth this late in life is that she did not set out to get pregnant using reproductive technology. She conceived entirely naturally and unexpectedly.

"We were incredulous," she told Australian newspaper *The Age*. "I turned around to look behind me when the doctor told me, I asked him if he was talking to me." Carmelina is now 11 years old and her parents are retired.

It is much publicised stories like this that give women in their fifth, sixth or even seventh decade the idea that it might not be too late to have children after all. In rich countries, many women today don't even start to think about having children until well into their thirties, if then. It seems that now we are in control of our reproductive capabilities, education and careers are the priority for many women.

Another factor could be that men are baulking at the prospect of having babies. Without a partner, relatively few women are prepared to go it alone. Whatever the reasons, many women have become the living embodiment of that 1980s T-shirt: "Oh my god! I forgot to have a baby!"

An estimated 1 in 5 British women in their mid-forties are now childless either through choice or because of a lack of opportunity, twice as many as 15 years ago. The trends are similar in the US and Australia. Meanwhile, women who are having children are leaving it later and later, with the average age of first-time mothers now standing at 27 in the UK, up from 24 in 1970.

And this average does not tell the whole story. The most dramatic changes have been in older age groups. In the US, the number of women giving birth for the first time between age 35 and 39 rose by 36 per cent between 1991 and 2001. For women aged 40 to 44, there was a staggering 70 per cent increase. In 2002, 263 babies – first or otherwise – were born to women between 50 and 54 years old. So will improvements in fertility treatments and pregnancy management allow women to delay childbirth ever later? And is this trend a cause for concern or celebration?

For now, the outlook is not brilliant for someone just starting to contemplate the patter of tiny feet at 40-something. Under the age of 30 a woman has around a 40 per cent chance of getting pregnant in a year, but by age 45 that figure plummets to a mere 10 per cent. And getting pregnant is only the first hurdle: as eggs age, the risk of miscarriage soars from 10 per cent at 20 years old to well over 50 per cent above 45.

Still, if your eggs are still healthy enough at 42 or 43 for you to get pregnant and stay pregnant, you have a pretty good chance of a safe delivery, although not as good as your younger sisters. The number of stillbirths, for instance, rises from 1.1 per 1000 births in women under 35 to 4 per 1000 in women over 40. "Stillbirths that come out of the clear blue are just devastating," says Linda Heffner, an expert on maternal and fetal medicine at Boston University Medical Center.

The 40-something is also more likely to be obese or have high-blood pressure or other chronic disorders. These increase the risk of problems such as gestational diabetes, which can lead to an unhealthily large baby, and pre-eclampsia – pregnancy-related high blood pressure. Pre-eclampsia can cause strokes, seizures, kidney and liver damage and occasionally death. It can also restrict a baby's growth and lead to premature birth.

These risks rise rapidly for older mothers, according to a study by Richard Paulson of the University of Southern California in Los Angeles of women aged 50 to 63 who used donor eggs and IVF. While the conception and miscarriage rates were identical to those for younger women using the same methods, mild pre-eclampsia developed in a quarter of the 55 pregnancies, even though the women had all passed a fitness test. A further 10 per cent developed severe pre-eclampsia. For those over 55 years old, pre-eclampsia rates shot up to 60 per cent.

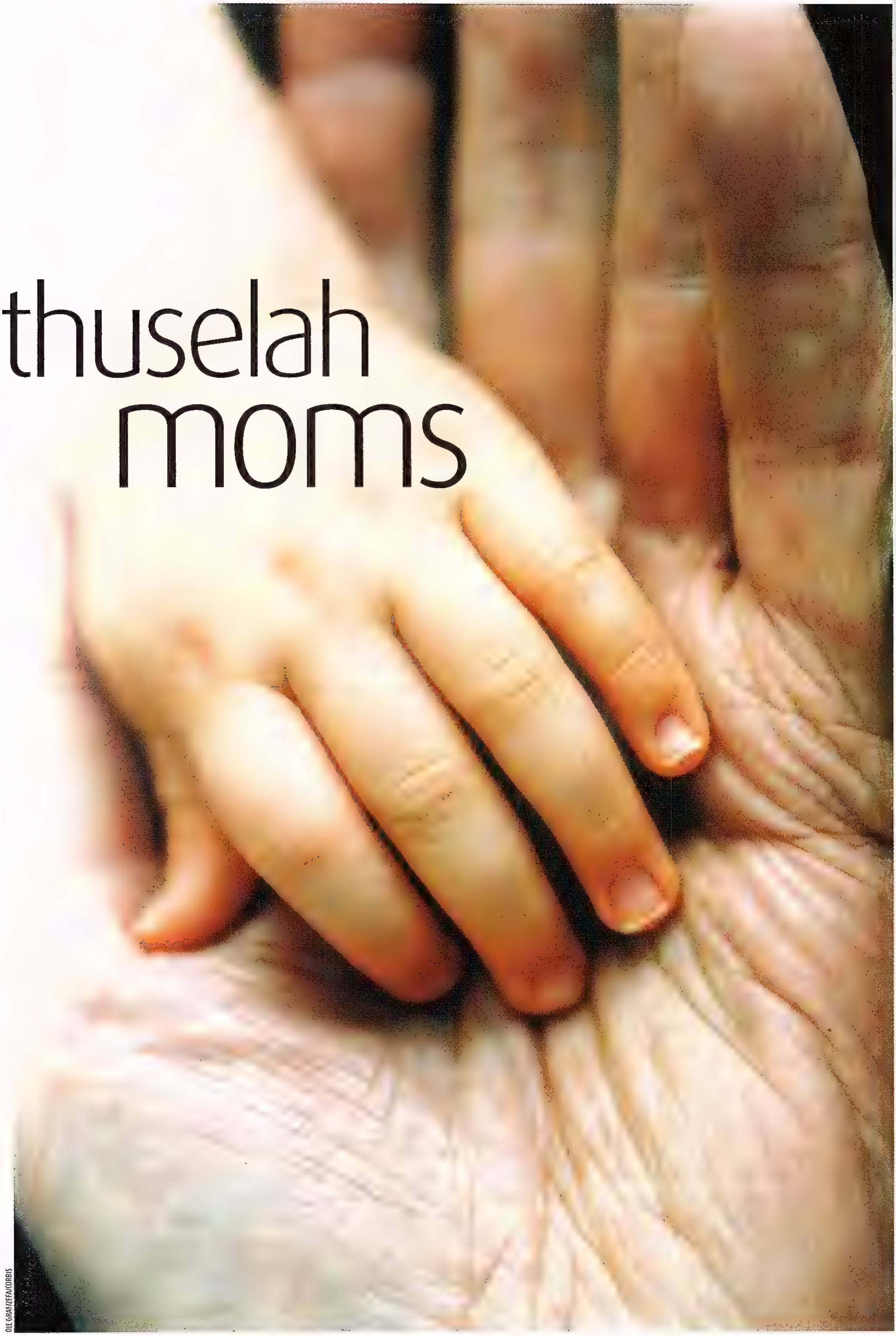
Gestational diabetes showed similar patterns, with a fifth of women needing to alter their diets or take insulin. Four of the 10 women over 55 suffered gestational diabetes.

What about the risks to the children? In the USC study, 10 pregnancies ended in miscarriage, but the 45 babies born were all within the normal range for weight and generally healthy. Nonetheless, if you start

When is best?

Under 25	**The younger you are, the higher the risks for you and your child**
25 to 35	**If you have the choice, this is the best decade to reproduce**
35 to 45	**The risks rise rapidly. If you have no health issues such as obesity or poorly controlled diabetes, you'll likely have a healthy delivery. But getting pregnant can be hard, and for many women over 40 IVF with donor eggs is the only option**
45 to 55	**You will almost certainly have to use donor eggs, and your health will be put to the test in more ways than one – clinics carry out a battery of checks before accepting women**
Over 55	**With donor eggs, it's happening far more frequently, but still very rare. The oldest woman in the world to give birth was 66-year-old Adriana Iliescu in January last year**

Methuselah moms



OLE GRAF/ZEFA/CORBIS

"Everyone wants to protect their children. No one wants them to go through the horror another family member did"

Needless to say, the issue is contentious. One of the main objections to sex selection is that it could skew the balance of the sexes. In many parts of Asia and Africa, male children are sought after. However, in western countries, the opposite seems to be true. "The vast majority of patients who come to us request girls," says Trina Leonard of the Genetics and IVF Institute in Fairfax, Virginia, which offers a sperm-sorting technique and PGD.

Many countries, including the UK and Australia, do not allow sex selection for non-medical reasons. Where it is allowed, some clinics restrict sex selection to family balancing, meaning a couple must already have a boy if they request a girl and vice versa. "You can't come here and say 'I want a family of five boys'," says Leonard. But half of the clinics in the US that carry out PGD for sex selection do not insist on family balancing, and many of their clients are couples from countries where sex selection is banned.

In the long term, it may be hard for regulatory authorities to continue to deny access to sex selection. "The reality is that the technology is available, and people want access to it," says Fishel. John Harris, a bioethicist at the University of Manchester, UK, sees no moral or ethical objection to sex selection. He suggests that a trial number of procedures should be allowed to see if fears about the social impact are justified.

How much further can selection go? What of that object of tabloid hysteria, the "designer baby"? Will we one day be able to ask for a tall, musical, blue-eyed boy or a dark-haired girl? Even if regulatory authorities allow us to use PGD to select desirable gene variants, there are major snags. For starters, IVF typically generates fewer than 10 embryos per cycle. This means parental choice will be very limited. "I don't think anyone in their right mind would ever go through IVF to select the hair colour of their offspring," says Yuri Verlinsky of the Reproductive Genetics Institute, Chicago, one of the pioneers of PGD.

"The only way to increase choice would be to generate larger numbers of eggs," says Handyside. It might become possible to do this by maturing early-stage eggs taken from the ovaries in the lab, or by generating eggs from stem cells (see "The egg and sperm race", page 52). Even then, the options will still be limited. "Unless we interfere with the genes of an embryo, children are going to resemble their parents," says Handyside. "The genes for particular characteristics may not be there."

What's more, predicting which of 100 embryos will turn into the most intelligent child or the greatest athlete will require enormous advances. "If tomorrow there was a publication saying that we have managed to identify all the genes involved in intelligence, then screening for it would be available in a few years," says Fishel. "But until there is a breakthrough in our knowledge it looks improbable that we could screen for amorphous traits like that, because we do not really know what they involve."

And the choices will not always be easy. Would you opt for gene variants that boost creativity if they also increased the risk of mental health problems, for instance? For would-be parents, simply understanding the information available will be difficult and the weight of decision-making will be far heavier. Even the decision not to screen will be a fraught one. It would be sad if this burden came to overshadow the thrill and wonder of bringing a new life into the world.

On the other hand, if screening for IQ does become possible there could be huge demand for it. Like it or not, we will be faced with new reproductive options – if societies choose to allow them. "We are going to have the technical ability to look at a very fine scale at the genetics of embryos in vitro and in pregnancy," says Handyside. "There are huge challenges for society to adapt and to work out where we should draw the line, what we should be looking for and what we should do with this information."

The battle over how this technology is used will shape the way future generations reproduce. The ethics of embryo selection will be pitted against the ethics of denying it to people who want it. Yet according to Harris, this is a false dilemma. "No embryo has a right to be implanted, and a woman has no obligation to have any embryo implanted if she does not want to," he says. "She makes a choice about which embryo, if any, to accept. I cannot see any justification for her being denied the information to make that choice rationally. "

"There should be no restriction on using PGD for diagnosing disease," says Verlinsky. "Everyone wants to protect their children; nobody wants to see them go through the same horror that someone else in their family did."

If people continue leaving childbirth ever later in life, there is no doubt that increasing numbers will have to resort to IVF. The growing advantages of PGD may persuade more and more fertile couples to join them. So will old-fashioned sex ever fall out of favour as a way of making babies? It is certainly not going to happen in the next 10 or 20 years, but in the next 50 or 100 – who knows? After all, who would have predicted how common IVF would become back in 1977, when Louise Brown was just a speck in a Petri dish? ●

Jo Whelan is a freelance writer based in France

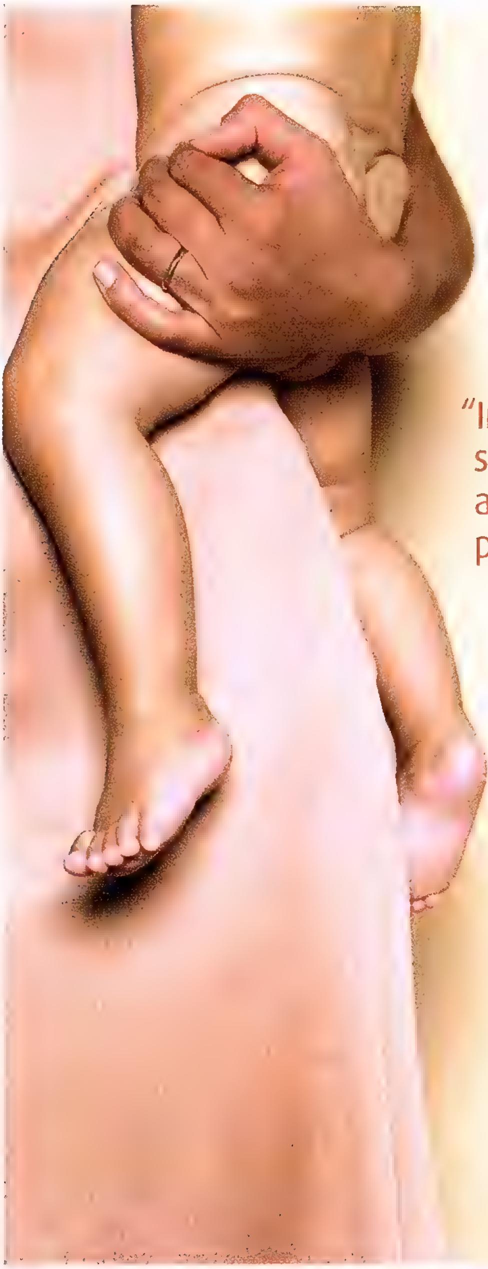
A window on the womb

You don't have to resort to IVF-PGD to screen for genetic disorders. Tests can also be carried out during pregnancy. Obtaining fetal cells involves invasive procedures that can trigger miscarriages, however, so such tests are usually done only if scans reveal an abnormality or if there's a high chance of a child inheriting a serious disease. Prenatal screening is also routine to confirm the results of PGD, which will never be 100 per cent reliable.

Most tests look for major chromosomal abnormalities, such as Down's syndrome. In Europe more than 90 per cent of fetuses with Down's are aborted, so fewer and fewer children are born with the disorder, despite the rising number of older mothers (see page 52).

More wide-ranging prenatal genetic tests are becoming available. Art Beaudet's team at Baylor College of Medicine in Houston, Texas, now offers screening for more than 150 different genetic abnormalities, using a technique called array-CGH to look for parts of chromosomes that have been duplicated or deleted.

Safer, non-invasive methods, such as isolating fetal DNA or cells from a mother's blood, could lead to prenatal genetic screening becoming more common. However, some geneticists say we do not yet know enough to routinely apply tests such as Beaudet's: the amount of information such tests can yield is growing faster than our ability to interpret it. And an abnormal result will always confront parents with the agonising decision of whether or not to terminate the pregnancy.



CAMERON/CORBIS

> "Imagine choosing your baby's sex and even aspects of their appearance or intellectual and physical capabilities"

children are 8 years of age they are indistinguishable from those conceived naturally. Other problems may emerge in old age, but it will be decades before we find out. There is a similar situation with PGD, which usually involves removing one or two cells from an eight-cell embryo for testing. Studies of children born after PGD have found no ill effects, but many experts question whether we can yet be certain the procedure is safe.

For the 1 in 6 couples with fertility problems, or those who know their children risk inheriting a serious genetic disease, IVF and PGD are already well worth the cost and risk. For the rest of us, of course, they are not. However, this balance looks certain to change as IVF becomes safer and more affordable and as PGD offers ever more possibilities.

Imagine if you could be almost certain that your child would be free of any known genetic disease. Not only that, you could choose your baby's sex and perhaps even select aspects of their appearance or intellectual and physical capabilities. Given these options, millions more people may be prepared to go down the assisted reproduction route.

"Any genetic defect that has been identified can now be screened for," says Alan Handyside of London's Bridge Fertility Centre, who led the team that pioneered PGD in 1989. As the genetic basis of ever more disorders is pinpointed, and more and more families discover that they harbour harmful mutations, the attraction of PGD will grow.

For the moment, though, with the exception of major chromosomal disorders, PGD can only detect mutations already identified in the would-be parents. It cannot detect unexpected mutations that arise spontaneously in the sperm or eggs of individuals who do not carry the mutation themselves. This will become possible, however, as our knowledge grows.

Part of the problem is that only one or two cells are available for screening. Until recently this greatly restricted the tests that could be done. However, new ways of amplifying DNA are making it possible to do hundreds of tests. That means clinics will be able to screen for a much wider range of harmful mutations – and for desirable variants too.

It is already easy to determine sex, and thousands of fertile couples are now choosing to have IVF-PGD for sex selection, as it is more reliable than competing methods such as sperm sorting. A recent survey found that 9 per cent of PGD in the US is for sex selection (*New Scientist*, 30 September, p 15), and the phenomenon is not restricted to western countries: in sub-Saharan Africa, for instance, more and more fertility clinics are offering this service, says fertility expert Osato Giwa-Osagie of Lagos Teaching Hospital in Nigeria.

In vitro figures

30,000 IVF children were born worldwide in 1989 and at least 200,000 in 2002

Well over 3 million children worldwide have been conceived by IVF since 1978

In Denmark and the Netherlands 1 in 25 babies are conceived in a dish

Will we one day come to see natural conception as irresponsible, asks **Jo Whelan**

have some embryos created and pick the one or two that will produce the healthiest baby.

IVF has become commonplace, and top clinics boast pregnancy rates of more than 30 per cent for each cycle – better than the 1 in 4 chance of conceiving the natural way and likely to improve further. Until recently, though, IVF was only for those with fertility problems. The rapid development of pre-implantation genetic diagnosis is starting to change this. Increasing numbers of fertile couples with a family history of a serious disease such as cystic fibrosis are opting for IVF with PGD so they can be sure any child will not inherit it. Others are resorting to IVF-PGD so they can choose their child's most basic characteristic: sex. Women who freeze their eggs to ensure they can have children later in life (see "Methuselah moms", page 46) may soon swell the ranks even further. Could IVF-PGD one day become the preferred method of conception?

"It is technically possible," says Simon Fishel, a member of the team responsible for the birth of the first IVF baby in 1978, who now runs the Care Fertility group of clinics in the UK. There are, of course, huge obstacles, not least of which is the cost. "You have to pay per cycle," points out Fishel. "You can attempt to conceive naturally over 12 cycles in a year and it costs you nothing."

If the benefits were clear, though, many couples might save up to give their children the best start in life, just as many now pay for private schooling. In some countries, state healthcare systems or medical insurers might foot the bill, at least for those who risk passing on severe diseases. New Zealand is leading the way, providing limited funding of IVF-PGD for couples whose children risk inheriting serious diseases. It remains to be seen how many countries will follow suit, but there is a strong ethical argument for offering prospective parents this option and, given the huge costs of treating many genetic illnesses, a strong financial case too.

The other big obstacles are the inconvenience, pain and risk involved. Women have to inject themselves for weeks with expensive hormones that stimulate their ovaries to produce more eggs than normal and then have the eggs extracted, with only a 1 in 3 chance of getting pregnant. It's an emotional roller-coaster ride.

In up to 10 per cent of IVF cycles the extra hormones trigger ovarian hyperstimulation syndrome, in which fluid leaks from blood vessels, causing symptoms such as bloating and pain. Around 5 per cent of cycles cause moderate or severe OHSS, with a risk of disabling strokes or even death. For every 100,000 women undergoing IVF, about six die.

While the hunt is on for ways to prevent hyperstimulation, it would be best to avoid ovary-stimulating drugs altogether, not least because there are fears that they might slightly increase the risk of some cancers. One alternative is in vitro oocyte maturation, or IVM. Early in the cycle the ovaries contain many eggs that are nearly mature, but only one completes development each month; the others degenerate. Instead of relying on drugs to force all these eggs to reach the ovulation stage, IVM involves harvesting nearly mature eggs and incubating them for one or two days to complete their development.

Several hundred children have already been born after IVM, and follow-up of the children has so far not revealed any ill effects. As well as being less risky for women, IVM is cheaper. "It is impossible to say if IVM will replace conventional IVF; its efficiency, efficacy and safety are still far from certain. But it could happen," says Fishel.

What about the health of the children? The greatest threat is the practice of implanting several embryos to boost the chances of a pregnancy, resulting in more twins and triplets, who face far greater health risks than singletons. They are more likely to be born prematurely or have a low birthweight, with all the lifelong problems these can entail, and to die soon after birth.

Even singleton IVF babies are around twice as likely to be premature or low birthweight. Again, however, multiple embryos could be to blame, because many IVF pregnancies start out as twin pregnancies. When single embryos are transferred, the differences in health vanish (*New Scientist*, 25 June 2005, p 14). Many countries limit the number of embryos that can be implanted and single embryo transfer could eventually become the norm.

An IVF baby is also three times as likely to be born with Beckwith-Wiedemann syndrome, which can lead to growth abnormalities and cancers. There are just 4 cases per 15,000 births even after IVF, however, and the higher risk might be due to parents' fertility problems rather than to IVF.

Despite these issues, by the time IVF ▶

Jargon buster

IVF	**Used here to refer to any form of fertilisation outside the body. Doctors, however, distinguish between conventional IVF – placing sperm with an egg in a dish and leaving them to it – and ICSI (intracytoplasmic sperm injection), where a single sperm is injected into an egg.**
PGD	**Pre-implantation genetic diagnosis. The testing of IVF embryos before implantation by removing one or more cells for analysis. Also refers to the testing of eggs before fertilisation. Not to be confused with prenatal testing during pregnancy.**
IVM	**In vitro maturation. A new method that involves collecting immature eggs and maturing them outside the body, instead of using drugs to stimulate women to produce many mature eggs. Its safety is not yet clear.**

sex is for fun IVF is for children

DUSTIN HARDIN/GETTY

IN THE science fiction movie *Gattaca*, the hero, Vincent, is an "In-Valid" – someone whose only crime is to be conceived in a moment of passion rather than in a Petri dish. His brother, by contrast, is a Valid, created by a process designed to ensure the optimum recombination of his parents' genes. In-Valids are condemned to a life of menial jobs and discrimination. To realise his dream of becoming an astronaut, Vincent has to buy a Valid's identity.

It's a scenario that is difficult to imagine from today's viewpoint. Yet could we be moving towards an age in which entering nature's genetic lottery is no longer seen as a desirable way to bring a child into the world? Might natural conception even come to be thought of as irresponsible, as bad as smoking while pregnant?

Reproducing the traditional way is undoubtedly flawed. Worldwide around 1 child in 16 is born with a mental or physical disability due to a genetic defect, and most of us probably carry gene variants that predispose us to serious illnesses later in life. How much safer it would be to go along to the fertility clinic,

Future child

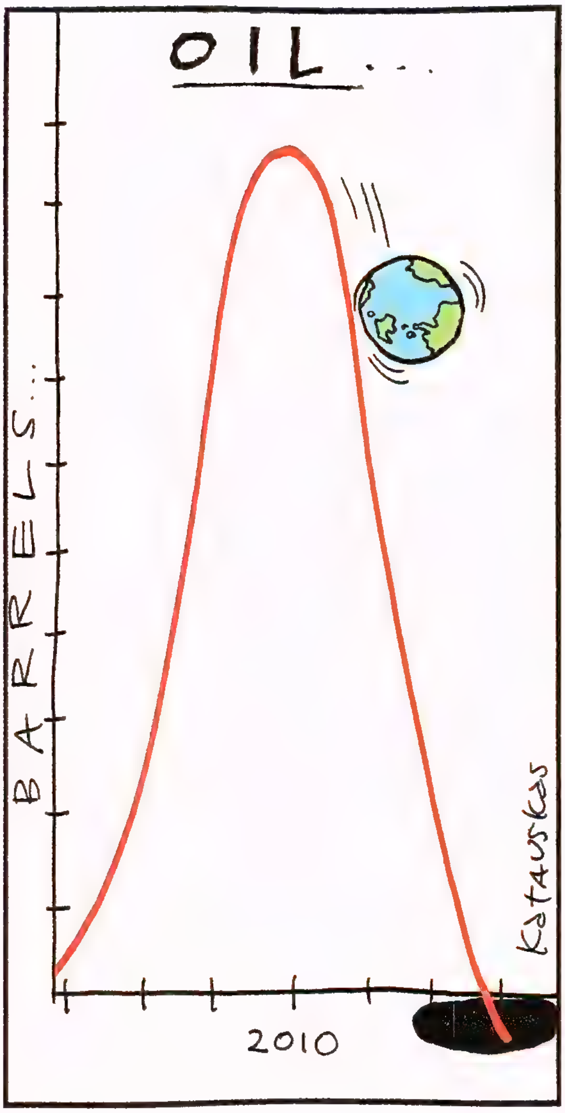
DUSTIN HARDIN/GETTY

Having children is not what it was. In rich societies we are having ever fewer children, ever later in life. And we are on the brink of even bigger changes. Astonishing advances in fertility treatments have enabled women over 60 to give birth. For the first time, making babies need not be a genetic lottery – a few parents are already choosing their children's genes. Soon even eggs and sperm might not be essential... In this special report, *New Scientist* looks at the future of reproduction

p42 Sex is for fun, IVF is for children

p46 Methuselah moms

p52 The egg and sperm race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an alpha particle inside the nucleus, making it harder for the particle to escape.

"Encasing radioisotopes in metals and chilling them could slash millennia off their half-lives"

Zinner says these two effects pretty well cancel each other out. If anything, he calculates, implanting a radioisotope in metal should slow down its alpha decay by a minuscule amount, which is not what we want. "The lifetime should actually increase, if anything, but by a very small amount of about 1 per cent or less in most realistic cases," he says.

This isn't the only reason put forward to suggest that Rolfs's model may be on shaky ground. Other physicists question its prediction that the rates of alpha decays will increase as the temperature falls. The model assumes that the average energies of conduction electrons in a metal are proportional to their temperature, and so they become more sluggish and crowd closer to a positively charged nucleus when they are very cold. This, however, flies in the face of theories which say that even at normal temperatures the electrons will already be crammed into their lowest possible quantum energy states. Only by heating them to tens of thousands of kelvin will they move to higher energy states.

"Warming them up from 1 to 300 kelvin makes almost no difference at all," says Nick Stone of Oak Ridge National Laboratory in Tennessee. If alpha decay rates could really be changed as radically as Rolfs suggests, we'd already know about it, he adds. For more than four decades his group has studied the decay of many radioisotopes, including the alpha emitter radium-224, in iron chilled to a whisker above absolute zero. They did this to test fundamental theories about how radioisotopes decay when aligned by strong magnetic fields experienced by trace nuclei surrounded by cold iron atoms. If there had been dramatic changes in alpha decay rates at low temperatures, they should have stuck out like a sore thumb during the checks and balances in his experiments, he says. "Either we've been totally asleep, or this huge change in alpha decay rates just isn't there."

Nevertheless, Rolfs is standing by his results. His preliminary experiment on alpha decay has shown some promise. For this, he implanted the alpha emitter polonium-210 into copper and chilled the samples to 14 kelvin (see Diagram, page 38). His measurements, as yet unpublished, suggest that the polonium half-life shortened by about 10 per cent. That's still a far cry from the 95 per cent his model predicted, but he is confident that refinements to the experiment should cut the half-life further. Improving the purity of the metal samples, for instance, and implanting the radioisotopes deeper inside should help, he says. Most of all, he hopes to run tests with a long-lived element like radium-226. Experiments, not theory, are the key to understanding nature, he insists. "If the alpha decay of radium-226 can be made very short, I don't need any theory. It will just be a fact."

Rolfs is now working on more tests with physicists at CERN. A facility there called ISOLDE creates and accelerates beams of tailor-made nuclei. ISOLDE could easily implant radium-226 nuclei into metals, and equipment at CERN or elsewhere could then test the alpha-decay rates at temperatures as low as 0.01 degrees above absolute zero. "The experiment would actually be very easy – it's beautifully simple," says Karsten Riisager from the ISOLDE team, which plans to seek approval for the experiment from a CERN committee later this year. "Within one year, we'd hopefully have the first scientific results, and within a couple of years we should have settled the matter," he says.

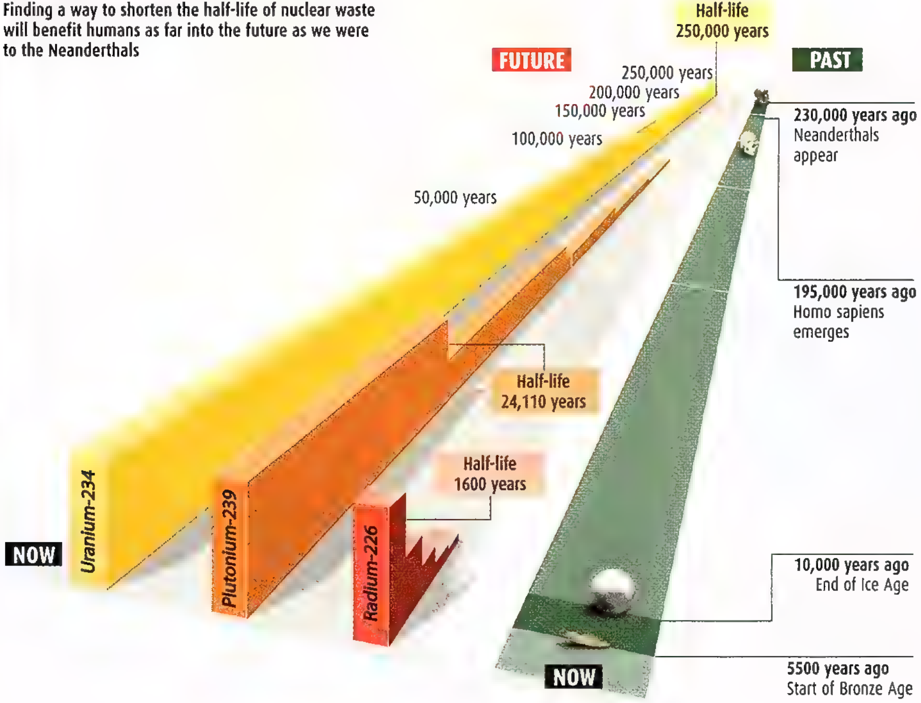
Rolfs says that if his theory stands up it might not only help rid us of radioactive waste but could also shed light on a long-standing puzzle about the Earth. Some of the heat produced in our planet's interior comes from the radioactive decay of uranium and thorium. Yet there is more heat than anyone can account for (*New Scientist*, 7 August 2004, p 26). Rolfs suggests that in the molten metallic environment of the Earth's core, uranium and thorium could be contributing to the excess heat by decaying faster than we imagined. Tweaking radioactive decay rates might also change estimates of the ages of the oldest stars, and hence the universe itself.

No one has yet thought these ideas through, because the research is still only months old. Scientists need far more proof that half-lives really can change radically. "Even if the effect is only 10 per cent, it would still be scientifically interesting," says Walker. "Anything that opens up a new avenue with nuclear physics could go down surprising routes."

For Rolfs himself, it is the possibility of dealing with the nuclear waste problem that is a bigger pull. "All my life, I used taxpayers' money to study something completely impractical," he says. "You cannot buy or sell anything from stars. If at the end of my career I can do something useful, this would be a wonderful payback." ●

NUCLEAR HALF LIVES

Many radioactive isotopes have extremely long half-lives. Finding a way to shorten the half-life of nuclear waste will benefit humans as far into the future as we were to the Neanderthals



Waste disposal

JUST suppose that Claus Rolfs is right, and that lab experiments can slash the lifespan of certain dangerous radioactive elements by thousands of years. Could that be scaled up into a useful technology to tame tonnes upon tonnes of dirty, real-world nuclear waste?

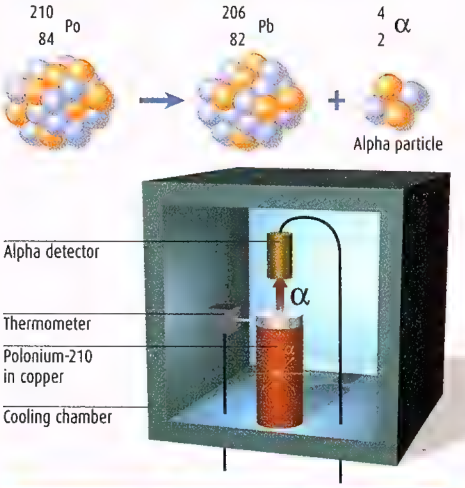
Rolfs sees no reason why not – though neither he nor anyone else has investigated this in detail. Rolfs envisages that the changes can be brought about by encasing the isotopes in a block of purified metal and chilling it to a few degrees above absolute zero. So the first challenge would be to select a suitable metal: one that does the trick in the laboratory, is cheap and ideally has a low melting point. It would then be necessary to melt the metal, stir in the nuclear waste, leave it to solidify, then bury it underground and keep it cooled to very low temperatures for as long as it takes to become harmless.

It's straightforward enough in principle, but many practical questions remain. What is the best waste-to-metal ratio? The metal would need to be kept pure, but how would this be done? How low a temperature would be required? Would cooling tonnes of metal to the desired temperature for years on end consume so much energy that it outweighed energy generated by the reactor in the first place? Rolfs argues that lab-scale technologies can keep metals cooled to 12 kelvin using no more power than a household freezer, and that scaling this up to an industrial process might well be technologically realistic.

"The basic physics still needs to be checked and I cannot predict all the practical hurdles," says Rolfs. "But you have to have an optimistic outlook or you wouldn't even start. Maybe we'll be lucky." If so, he predicts that we'll have a practical way to dispose of waste within 10 or 20 years.

JUST ADD METAL

Claus Rolfs believes it is possible to decrease the half life of polonium-210 by encasing it in copper and chilling to 14K



Polonium-210 half-life	In metal at room temperature	In metal at 14K
Conventional prediction	138 days	138 days
Rolfs's prediction	73 days	6.9 days

of each sample made at room temperature, and then at 12 kelvin, the team estimates that beryllium-7's half-life in chilled metal increases by about 0.8 per cent. This is slightly less than the model's prediction of 1.1 per cent, but definitely in the expected direction (*European Physical Journal A*, vol 28, p 375). The team didn't stop there. Similar tests with sodium-22, which undergoes beta-plus decay, showed that the normal half-life of 2.6 years shrank by about 1.2 per cent in metal at 12 kelvin. This was far less the model's prediction of 14 per cent. But again, Rolfs is encouraged that the effect is in the direction that his model predicts (*European Physical Journal A*, vol 28, p 251).

Perhaps the most striking result to date comes from an experiment this year in which Rolfs bombarded a sliver of highly purified gold-197 – the metal's normal stable isotope – with neutrons. Some of the gold atoms absorb a neutron to create radioactive gold-198, which undergoes beta-minus decay with a half-life of 2.7 days. With the gold-198 atoms surrounded by ordinary gold, Rolfs's model predicts that their half-life should increase by about 1.7 hours, even at room temperature. Conveniently, he could now measure the half-life directly, by counting the gamma rays released during the beta decay, and timing how long the count took to halve. The results, which are still to be published, amazed him. It turned out that the half-life actually increased by a whopping 5 hours. "I'm astonished myself – I didn't expect such a large effect," says Rolfs.

Now his team is starting experiments with alpha decay, which interests Rolfs most of all. That's because his model predicts truly stupendous changes for alpha decay. Take the alpha emitter radium-226, which has a half-life of 1600 years. The model hints that by encasing it in a metal and chilling it to about 4 kelvin, it might be possible to slash its half-life by a factor of 1000, to less than two years. If that turns out to be what happens, it could have huge practical implications.

Radium-226 is a component of spent fuel from nuclear power stations and the sludge left over from uranium mining. It will pose a health hazard for more than 50 generations to come. "Our great-great-grandchildren may have to pay the price, and this is a justified criticism of nuclear power," says Rolfs. If his theory is correct, it might be possible to make the radium safe in our own lifetimes simply by mixing it into a pure metal and chilling it (see "Waste disposal", left).

This is a radical prediction, to say the least, and other physicists are finding it hard to swallow. "I'm deeply sceptical about it," says Phil Walker, a nuclear physicist at the University of Surrey in Guildford, UK. Despite this he welcomes what Rolfs is doing. "I always like people who are prepared to stick their neck out," he says. "He challenges the way we're thinking, and even if he's not right it will make us reconsider things and understand why he's not right."

Nikolaj Zinner, a theorist at the University of Aarhus in Denmark, says that physicists generally accept Rolfs's findings regarding nuclear fusion in metals. Zinner is also prepared to accept his idea that it might be possible to tweak beta decay rates in the way Rolfs suggests, but says alpha decay is an entirely different kettle of fish. That's because while beta decay is governed by the weak nuclear force, it's the strong force that governs alpha decay. To escape a nucleus, a positively charged alpha particle has to overcome the attractive strong force of other nuclear particles around it by penetrating an energy barrier, a process called quantum tunnelling. Zinner accepts that conduction electrons from a metal would, as Rolfs suggests, lower that barrier by increasing the density of negative charge surrounding the nucleus. The catch, Zinner says, is that they would also effectively decrease the energy of

heresy

FOR ALL its eureka moments, science has taught us many unpalatable lessons about what we are powerless to do. We can't dim the sun to remedy droughts or global warming. We can't stave off the ravages of time to live for thousands of years. And there's little we can do about radioactive waste from nuclear reactors that will be a health hazard for generations to come. Radioactivity cannot be tamed; all we can do is bundle the waste somewhere safe and wait for it to decay away. So it takes some nerve to say otherwise, and suggest that there are, after all, ways to speed up radioactive decay.

Yet that is exactly what Claus Rolfs, a physicist at the Ruhr University in Bochum, Germany, is doing. His dramatic – and controversial – claim is that by encasing certain radioisotopes in metal and chilling them close to absolute zero, it ought to be possible to slash their half-lives from millennia to just a few years. He says it's time to rewrite defeatist textbooks that insist we cannot alter the pace of radioactivity. "When I was studying physics, my teachers said nuclear properties are independent of the environment – you can put nuclei in the oven or the freezer, or any chemical environment, and the nuclear properties will stay the same," says Rolfs. "That is not true any more."

If Rolfs is right, it could have profound implications not just for nuclear waste management, but also for understanding the Earth's interior and measuring the age of the universe. So far, other physicists have reacted to his claim with an equal mix of scepticism and intrigue. Yet everyone is keen to see his idea put to the test properly, which could happen within the next year at CERN, the European centre for particle physics near Geneva, Switzerland.

Rolfs has spent most of his career studying the nuclear reactions that rumble in the hearts of stars. He heads the Laboratory for Underground Nuclear Astrophysics beneath Gran Sasso mountain in Italy, where researchers use accelerators to trigger low-energy nuclear fusion reactions similar to those in stars. His work has helped to establish precise values for the rate at which the nuclei of light elements fuse. In a typical experiment at Gran Sasso, researchers might fire a beam of helium-4 ions into a little cloud of helium-3 gas and measure how often the nuclei fuse to form beryllium-7 – a key reaction in the sun.

Then, around five years ago, Rolfs heard about some curious results from a lab in Berlin, where an international team of researchers was studying fusion of deuterons – a proton bound to a neutron – implanted inside different materials, including the metal tantalum. The team reported that when they fired deuterons into a deuteron-soaked sliver of tantalum, the deuterons fused with each other unexpectedly often (*Europhysics Letters*, vol 54, p 449). It was a startling result because conventional wisdom says that, as with radioactive decay, nuclear fusion rates should not depend on the environment.

Baffled, Rolfs asked his students to repeat the experiment at his lab in Bochum. Sure enough, they found the same effect. Rolfs went on to test the fusion rates of deuterons in more than 50 materials, from metals to semiconductors and insulators. Compared to fusion rates in a gas, rates in a metal were consistently higher, especially at low temperatures. "Until then, no one thought a nuclear property like the fusion rate could be enhanced by the environment," Rolfs says. "But it was – this was the first surprising news."

To explain these findings, Rolfs adapted a model developed by the Dutch physicist Peter Debye in the 1920s for the energetic ionised gases known as plasmas. Rolfs reasoned that like electrons in plasmas, the loosely bound conduction electrons in metals might cluster around positively charged deuterons. As the temperature drops, he argues, the electrons would cluster ever closer, generating electric fields that would accelerate other deuterons towards them, increasing the probability of deuteron-deuteron fusion. Rolfs has shown that this picture can be extended to heavier elements as well. His experiments verified that protons fuse more easily with lutetium-176, for instance, if the lutetium is inside a metal rather than an insulator (*Journal of Physics G*, vol 32, p 489).

Nuclear freeze

Radioactive decay can sometimes be like fusion in reverse, and this set Rolfs wondering: could a cold metallic environment influence decay just as it influences fusion? If a radioactive nucleus was inside a metal, perhaps the metal's conduction electrons might help accelerate a positively charged particle out of it, Rolfs reasoned; that should enhance alpha decay, in which a nucleus emits an alpha particle (a helium nucleus). The same would apply to a radioactive process called beta-plus decay, where a proton converts to a neutron and emits a positron. Conversely, being inside metals should hinder electrons leaving or entering a nucleus, which is what happens in conventional beta-minus decay and another process called electron capture, which involves a proton in the nucleus combining with an electron to form a neutron.

Using his simple model, Rolfs has come up with ballpark estimates for how much the half-lives of different radioactive nuclei should change inside metals. Some changes are subtle, he calculates, while others are sky-high – certainly large enough to make a real difference to the longevity of radioactive isotopes. That, at least, is the theory. Now Rolfs is starting to run lab experiments to see whether these changes occur in practice.

In one of these tests, he and his colleagues prepared samples of beryllium-7 implanted inside the metals palladium and indium. Beryllium-7 naturally decays via electron capture with a half-life of 53 days. Rolfs and his team did not directly measure the half-life of beryllium inside metals but measured the decay rate, which counts the number of electron captures per second.

From measurements of the decay rates ▶

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[illegible]

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'Don't take that road, it'll be jammed solid'

FEW things are more irritating than leaving a busy road to avoid a traffic jam, only to find that everyone else has had the same idea and you are stuck behind yet another queue.

Now a smart electronic map has been developed to help drivers find the best route, using information on nearby roads together with the day of the week, time, weather conditions and the speed of traffic on nearby roads. Crucially, the software can use road configurations it already knows about to predict how traffic on unfamiliar ones will behave.

Route-planning systems have been developed before to predict when jams on major roads will ease, or when traffic will start to snarl up. However, these are based on how traffic on the road has behaved in the past, and cannot advise drivers about minor roads that haven't been monitored, says Eric Horvitz at Microsoft Research in Redmond, Washington. "When the highway is crowded, you can't just say 'use the side roads', because they flex as well."

The new model designed by Horvitz and his colleagues, called ClearFlow, extends traffic predictions to all roads. "We are even able to reason about streets we have never seen before," he says. To create the system, the team handed out GPS trackers to volunteers in Seattle to constantly record their vehicle's position, giving the speed of the vehicle on each road it travelled along. The volunteers carried the trackers around for two weeks before handing them to others to do the same. After three years all the results were collated to form a database of vehicle speeds for each road at different times of day and under a range of conditions.

Horvitz's team then used software to mine public databases for information on these roads, including the number and type of traffic lights, the frequency of junctions, their distance from major highway exits and schools, whether they are rural or urban, number of lanes and so on. By combining this data with the information from the GPS devices, Horvitz was able to train the model to predict with 80 per cent accuracy how all side streets would react to changing traffic speed on the main arteries, even if those streets had not been monitored in the initial survey.

The team's smart map of Seattle is being tested by Microsoft employees and could be available online via Windows Live next year. Ultimately Horvitz hopes to extend it to other major cities, without needing to send more GPS-equipped volunteers onto the streets.

> **"The new model extends traffic prediction to all roads, even streets we have never seen before"**

Mike Liebhold, a geospatial map specialist at the Institute for the Future in Palo Alto, California, says the idea is exciting. "I think this is something people will use." **Celeste Biever** ●

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Can these touch-screen voters in Florida, 2004, be sure what happened next?

that can be taken away from the polling booth are a big no-no, because giving people proof of how they have voted makes it possible for them to sell their vote to anyone hoping to rig the election, or be intimidated. This is where cryptography can help, because it allows a voter to verify their vote online without revealing who they voted for.

A number of such systems have been designed (see "Your next ballot paper could look like this", opposite), all of which use a series of encryption steps, each undertaken by a different election teller. Firstly, a template of the ballot paper for each voting district is created electronically, with a list of candidates and spaces for the voters to mark their choice. This is then copied so that there are enough individual electronic papers for all the district's registered voters, and the copies are passed to the tellers. The first teller electronically shuffles both the order of candidates on each paper and the order of the papers, and then for each paper generates a unique code that describes what shuffling has been done. This code is encrypted and added to the bottom of the paper.

The ballot papers – still in electronic form – are then passed to a second teller, who shuffles the order of candidates on each paper and the order of papers once more, and creates their own encrypted code for each paper, which is added to the first. More tellers can be used to add further layers of shuffling before the ballot papers are printed out.

When the voter goes to the polling station on the big day, they take one of these coded papers and mark their chosen candidate, as usual. Then they rip their ballot paper up.

This is not a political protest. The ballot paper is designed to be torn into two pieces, neither of which on its own can show an unauthorised third party which candidate the voter chose. One or both of the pieces, however, carries the tellers' code, which holds the secret of deciphering that individual ballot paper and the mark the voter made on it. The voter puts one piece into a shredder and takes the other, now inscrutable slip to a machine that scans it. The voter takes this half-ballot away with them.

The ballot's scanned image data is sent to the second teller's computer, which decrypts the second teller's segment of the code and uses it to unshuffle the order of candidates and papers. The resulting data is then sent to the first teller, who in turn undoes their shuffling to reveal the order of candidates that the voter saw. The vote can then be awarded to the matching candidate. In this way, the second teller knows the full code on the ballot sheet, which ties the vote to the voter, but not the name of the chosen candidate. The first teller, in contrast, knows the chosen candidate, but with only a fragment of the code has no way of finding out who cast the vote. To prevent tellers sharing their codes to connect the voter with their vote, cryptographers such as Chaum recommend tellers come from opposing political parties.

What makes the system tamper-proof, however, is that the voter can check that their vote has been counted correctly. They simply go to a public website and key in the encrypted code from the part of their ballot paper that they marked, scanned and took away. If their vote has been registered properly, this will bring up an image of that same ballot, with the mark in the correct box, but crucially will not reveal the name of their chosen candidate.

If such schemes are to succeed in preventing fraud, voters must be proactive, either in checking their ballot themselves or giving it to an organisation such as the American Civil Liberties Union for checking. Only a few would need to do this, however, to ensure the integrity of the election.

Persuading the public to accept such complex schemes may be tough. Rubin, however, is optimistic. "We need to get to the point where the public trusts that these systems work, the way they trust that an airplane will work," he says, "despite the fact that they don't have a degree in aeronautical engineering." ●

"The future lies in systems that allow a voter to verify their vote has been counted correctly"

E-voting you can trust

In an electronic ballot, secret codes and torn-up voting slips could be the best guardians of democracy

CELESTE BIEVER

IT IS election day. You step into the polling booth and place a mark against your chosen candidate on the ballot form. You then take your ballot to a machine that scans the paper and displays it on-screen for you to confirm. It appears as if everything has gone smoothly, but how can you be sure the computer has awarded your vote to the right candidate?

When US voters go to the polls for mid-term elections on 7 November, the vast majority will rely on software to tally their votes, either by using an optical scanner like this or a touch-screen machine. Electronic vote-counting is attractive in the US, where complex ballot forms typically contain dozens of different choices, making them difficult to sort by hand.

The question is: can these e-voting machines be trusted? Over recent years voters have come to doubt it. In July 2003 computer scientist Avi Rubin at Johns Hopkins University in Baltimore, Maryland, claimed that flaws in touch-screen voting machines built by Diebold Election Systems of McKinney, Texas, meant that a single voter could cast many votes without leaving any evidence of their fraud. As a result, over half of all states now insist that votes cast electronically are accompanied by a paper copy that is deposited in a box to be checked if vote-rigging is suspected.

More and more experts argue this is not enough. Paper votes can be lost or become illegible, either through faulty printers or foul play, while software bugs and malicious programs that delete or flip votes could go undetected. "It's a black box," says Rick Carback, a computer scientist at the University of Maryland, Baltimore County. "Once you give the machine your vote you don't know whether it has been counted or not."

Carback and others believe the future lies in voting systems that use cryptography to protect voter privacy, while allowing a voter to verify that their vote has been counted correctly. "Cryptography can shoot dead the voting problem," says David Chaum, a cryptographer based in Los Angeles who pioneered the field of crypto e-voting.

As well as preventing fraud, such systems could also help avoid disputes over election results, such as the protests that followed Mexico's presidential election in July, by reassuring voters that the election is above board. By increasing voter confidence in the system, they could also encourage more people to vote, Chaum says.

The main difficulty with all voting systems is finding a way to allow people to confirm that their vote has been counted without also allowing them to prove to someone else how they voted. For example, hard copies of ballots

MARIO TAMA/GETTY IMAGES

YOUR NEXT BALLOT PAPER COULD LOOK LIKE THIS

Cryptographic electronic voting systems were first proposed four years ago, but the schemes were far too complicated for practical use.

In recent months a new generation of much simpler schemes has appeared. "Researchers are making progress in taking the basic concept and turning it into something closer to a real system that could be deployed in practice," says David Wagner at the University of California, Berkeley.

One such system, called Prêt à Voter, has been developed in the UK by Peter Ryan, a cryptographer at the University of Newcastle upon Tyne. Prêt à Voter ballots consist of a sheet of paper perforated down the centre, with candidate names in random order on the left and a column of boxes on the right. Voters mark the ballot in almost the same way as British voters do today, putting a cross in the box next to the candidate they select. They then tear the sheet in two, shred the side with the candidate names and scan the column of boxes. An encrypted code on each paper is used to reconnect the marked box with the candidate.

Meanwhile David Chaum, a cryptographer based in Los Angeles, has developed a similar system called Punchscan. This uses two overlaid sheets of paper. On the top sheet is the list of candidates, and alongside each are two holes, above which is printed "a=yes, b=no", or vice versa, though the holes themselves are not labelled. On the bottom page, printed so they show through the holes, are the letters "a" and "b", in random order. On both sheets is an encrypted code that, when decrypted, reveals the order of "a" and "b" for each candidate.

The voter makes a selection by marking around one hole with a large felt-tip pen. The pen marks both sheets, and the voter pulls the sheets apart, shreds one – it doesn't matter which – and scans and keeps the other.

In both systems, the marked ballot paper is torn apart so that neither part reveals which candidate the user has voted for, but either can be used to reconstruct the person's vote if you can decrypt the code.

Chaum says the main advantage of Punchscan is that, unlike Prêt à Voter and other systems, tellers use secret keys to encrypt and decrypt the code, rather than using public-key cryptography, a widely used technique in which a publicly available key is used to encrypt a code and a secret key is used to decrypt it. "Public-key encryption is wonderful but very few people have any deep understanding of it," he says. "Even a 10-year-old can relate to secret codes," he says.

TV BRIDGES BROADBAND GAP

You'll have heard about television over the internet, but how about internet over television? Vacant TV channels could be used to provide wireless broadband internet services in the US, following a ruling last week by the Federal Communications Commission. The FCC decision is intended to stimulate increased broadband uptake in the US, which now languishes at 15th in the world for broadband uptake.

Most US analogue television networks are due to be switched off by 2009. The spectrum this frees up will be used mainly for digital high-definition TV, but there will still be many unused frequencies – particularly in rural areas. It happens to be these areas that are worst served by broadband networks.

The National Association of Broadcasters initially objected to plans to use these frequencies for wireless internet, fearing that the signals might interfere with pictures and sound on adjacent TV channels. So the FCC has said use of vacant channels – known as "white spaces" – will only be allowed to go ahead if wireless internet service providers can prove that no interference will occur. In addition, their devices must be capable of listening for TV signals and automatically tuning into vacant channels, to prevent a device bought in Texas, say, interfering with TV frequencies if used in New York.

"The US is in the midst of a broadband crisis stemming from a lack of build-out and grossly inadequate competition," says FCC commissioner Michael Copps. "Using TV white spaces is one of the truly promising opportunities before us that could provide a remedy."

LAYNE KENNEDY/CORBIS

Making space for the internet

MySpace for the dudes in lab coats

THEIR kids may have got there first but scientists will soon have their very own version of MySpace, where they will be able to share preliminary results, ideas and research tools.

Dubbed MyExperiment, the site will give the scientific community web tools such as social networking and the ability to rate software or tag it with keywords. "There are these great collaboration tools that 12-year-olds are using. It's all back-to-front," says Robert Stevens, a bioinformatician at the University of Manchester, UK, and a member of the team developing the site.

As well as sharing ideas, the team hopes the site will become a marketplace for swapping and modifying the software tools that bioinformaticians use to identify and characterise genes.

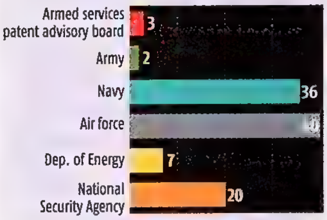
1.2

million Libyan schoolchildren will have $100 laptops by 2008, says the organisation One Laptop Per Child

SOURCE: THE NEW YORK TIMES

KEEP IT QUIET

Number of US government agency patents blocked by Pentagon secrecy orders in 2006



SOURCE: US PTA

Keep your fingers out of my account

"DIGITAL security" has just acquired a whole new meaning.

Fingerprint scanners are increasingly used to control access to buildings, devices and services, but fingerprints can be stolen by physically "lifting" them or by hacking into the biometric code stored on a device such as a laptop.

To prevent stolen prints being used to access bank accounts or computer files, London-based company fingerPIN has developed a security system that combines fingerprint recognition with a version of the traditional PIN – using a series of fingers rather than numbers.

Users register four prints in a sequence known only to themselves. So even if a thief were to steal a person's prints, they would still not know the correct sequence. The company and a UK retailer will conduct a trial of the fingerPIN system later this year.

GIZMO

The inhabitants of the virtual world Second Life now have their own news service. News agency Reuters opened a bureau in the online game on 18 October to report on the lives and business dealings of Second Life's 900,000 users. News stories, photos and videos will be filed to a dedicated website.

A new type of smart paper for use in electronic displays has been developed. Mangilal Agarwal and his colleagues from Louisiana Tech University in Ruston coated wood microfibres with a conducting polymer film about 20 nanometres thick (*Nanotechnology*, vol 17, p 5319). The new process uses much less of the expensive polymer than existing methods, which involve coating pre-made paper. The paper is also tougher, so it can stand up to more abuse while retaining its flexibility.

"Concerns about patient safety do not justify no-phone areas"

Stuart Derbyshire of the University of Birmingham, UK, and Adam Burgess of the University of Kent in Canterbury arguing that hospital restrictions on cellphones are based on unsubstantiated safety concerns and should be lifted (*BMJ*, vol 333, p 767).

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and suits the animals well.

What Singer fails to address is that the "factory" farming systems have been brought about by the cut-throat pressures of the modern food retail chain and the demand for ever cheaper food.

"Finished" cattle ready for slaughter are still not trading at even 80 per cent of the prices they were making in the mid-1980s but costs have almost universally risen. If the consumer wants ethical and holistic food they must pay for it, and the retailer must pass on the extra margin. This is where farmers' markets are working so well.

Hatfield, Hertfordshire, UK

Emdrive? No thanks

From Alvin Wilby, SELEX Sensors & Airborne Systems

The article about Roger Shawyer implies that EADS Astrium suppressed this miracle drive for nefarious business reasons (9 September, p 30). The truth (sorry, conspiracy theorists!) is rather different. As the then technical director of Astrium, I reviewed Roger's work and concluded that both theory and experiment were fatally flawed. Roger was advised that the company had no interest in the device, did not wish to seek patent coverage, and in fact did not wish to be associated with it in any way. The letters you have published point out some of the issues (7 October, p 24).

I was also surprised by the "end of wings and wheels?" tagline on the cover. Even if the device did work, the thrust/power ratio claimed by Roger would make it impractical for any terrestrial transport application.

Luton, Bedfordshire, UK

Our laws of nature

From Lassi Hyvärinen

Lee Smolin ponders whether laws of nature are immutable for ever – for example, Newton's model versus Einstein's (23 September, p 30). These theories are human-made, while nature was what it was before humans came about. We have invented these laws that are subject to improvements and evolution.

Scientists wonder how the universal constants are so fine-tuned that even small deviations would make the world impossible. This is a bottom-up concept. The top-down approach is that the possible universe exists and is the way it is. It is we who have found the models and constants that fit it. If the laws of nature were different in the early universe, we can never fathom them.

Divonne-les-Bains, Ain, France

The sun won't save us

From Gareth Jones and Simon Tett, Met Office, and William Ingram, University of Oxford

We were disappointed by the narrow focus of the cover story on global warming, which ignores most of the arguments against solar activity having a significant effect on recent climate change (16 September, p 32).

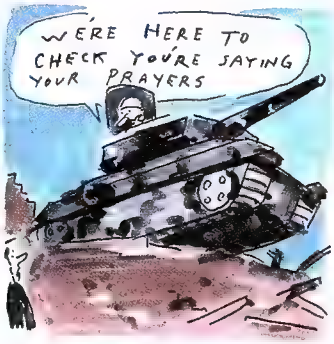
For instance, changes in volcanic activity can explain most, if not all, of the climate change in the last millennium that has been attributed solely to solar influence. Correlation with solar activity does not mean causation, especially when several different factors can influence climate. Both the Maunder minimum and the early 19th-century reductions in solar activity were associated with periods of increased volcanic activity. The latter includes the 1816 Tambora eruption, associated with the "year without a summer".

While some studies show a considerable link between solar activity and climate, most studies that include all potentially relevant factors find a much smaller solar contribution. Recent research by scientists at many institutions around the world, including ourselves, suggests that the sun may have made a detectable contribution to global warming in the early 20th century, but hasn't done so since 1950. Human and volcanic influences have swamped it since then.

To understand causes of climate change, we should take all plausible influences into account, as well as their often considerable uncertainties. When we do so, we find the sun's effect over the recent past is small compared with the impact of human-induced climate change. We will need to make considerable improvements in understanding both the physics of solar variations and the climate's response to those changes before we can have any confidence in what future changes in climate, if any, may be due to the sun.

Exeter, Devon; Reading, Berkshire; and Oxford, UK

Religion and evil


WE'RE HERE TO CHECK YOU'RE SAYING YOUR PRAYERS

From Nick Dore

While it is perfectly true that people do extremely unpleasant things to each other without the excuse of religion, as Mary Midgley reminds us, it hardly negates the point that Richard Dawkins makes in his new book *The God Delusion* (7 October, p 50).

It is important to realise that there was a definite religious dimension to the actions of the atheist regimes of both Stalin and Hitler, too. Both dictators had strong religious influences in their early lives: Stalin trained for the priesthood and Hitler had been an altar boy. Hitler retained a lifelong respect for the authority and rituals of the Catholic Church. Each understood the enormous power of religion and set out to use the trappings and techniques of the church to set up a form of "secular faith", using all the methods of religious indoctrination to form new societies every bit as intolerant as any preceding society fixated on religion.

They succeeded all too well, and their successors Pol Pot, Mao Tse-Tung and Kim Jong-il have continued the same systems. Faith without reason is the root of the problem, surely, and it all comes back to the God delusion.

Lincoln, UK

Retrocausality

From Carl Looper

The article on retrocausality seems to be implying that John Cramer and others are on the verge of sending messages back in time (30 September, p 36). They are not. Retrocausality is a conceptual model, not some factual aspect of the physical world requiring explanation. It tells us nothing about the world that we can't already understand by other means.

Such an experiment is important because although it won't succeed in sending messages back in time, it will succeed in showing how retrocausality is both redundant and a trap.

Bondi Beach, New South Wales, Australia

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Think small

From Jeremy Leggett, Solarcentury

George Monbiot accuses me of grossly over-hyping solar power in my book *Half Gone* (30 September, p 24). It was BP who originally asserted that solar photovoltaics could theoretically provide all the electricity the UK now uses if solar cells of existing efficiency were placed on all available roof space. I echoed that assertion, but Monbiot would have preferred me to cite a paper from a peer-reviewed journal rather than the publicity material of an oil company. Oil companies, after all, have a long record of saying how powerful and desirable a resource solar energy is, don't they? Monbiot in turn cites a think tank favoured by the Department of Trade and Industry which, using out-of-date efficiency information, says solar would fall short of providing all the UK's electricity.

Why don't we look at the track record and extrapolate from there? I myself have lived in a house that over the course of a year generated more electricity from a small solar roof than it consumed, with permanent occupancy and a daughter with an energy-vampire hairdryer protractedly in use on a daily basis. Why can't every house do that, theoretically? In most commercial and industrial buildings, there is more roof space than you would need to generate the load used.

I say "theoretically" because I never advocated trying to generate all the UK's electricity from solar, as Monbiot seems to imply I did. I advocate use of the complete mix of renewables, and of course the essential handmaiden of solar: energy efficiency.

Finally, Monbiot throws the cost of solar at me, this time citing that well-known supporter of new-energy thinking, the International Energy Agency (set up by governments to promote fossil fuels). Enough solar cells to generate all the UK's energy would be vastly expensive, says the IEA. What about economies of scale in manufacturing? If we did get to that kind of scale, the cost of manufacturing – already close to the cost of other forms of generation for the grid in Spain, Italy, Portugal and Denmark – would have plummeted below the point where solar electricity becomes cheaper than today's electricity.

London, UK

HOW MUCH CARBON EMISSION AM I SAVING PER CHAPTER?

From Tom Robertson

Monbiot's conclusion that "in almost all circumstances micro-wind turbines are a waste of time and money" is flawed, as it assumes that miniature replicas of offshore wind farms will always be the preferred choice. For domestic premises, his analysis can equally well lead to the conclusion that traditional wind machine layouts should now be abandoned in favour of arrangements specifically designed for this application.

For example: instead of regarding the effect that a house has on wind flow as a disadvantage, why not make use of the building itself, the largest surface area available, as the primary energy collector?

Technical problems are a challenge, not a full stop. Change the design to overcome identified problems rather than condemn the whole concept because one particular wind turbine configuration is unsuitable.

Abingdon, Oxfordshire, UK

From Arthur Krueger

I suggest that Monbiot visits a home such as ours that is not connected to the national grid, but is dependent on the low-wattage sources he eschews. He would find that it is very easy to combine these sources to provide virtually all of one's household electricity.

We run a small farm and an engineering business, and have raised three children on wind, solar and a 48-watt micro-hydroelectric generator. We have three computers, two freezers, a refrigerator, clothes washer, power tools and fax machine. This letter is being transmitted on one of these computers using this energy. The system is very reliable, and the main differences we see are that our lights stay on when a storm knocks out the electricity to our neighbours on the grid, and we make no payment to the electric company.

No sane person would attach a wind turbine to a house as Monbiot suggests. They are usually mounted on rather simple guyed towers. They are invariably shorter than the 65 metres that would be a hazard to aircraft that he worries about. No one has ever complained about our wind system.

Solar panels always face south in the northern hemisphere and not at "all points of the compass", as he suggests. Those facing north would be useless for generating electricity.

Monbiot needs to stop reading articles that measure in terawatts and visit some of us in the real world who measure in plain old watts. Home-generated electricity is definitely part of the solution.

Shrewsbury, Vermont, US

From Anthony Battersby, Mendip Power Group

Monbiot complains that potential buyers of home generators are being misled. It would be helpful if he distinguished between pico-generation (up to 10 kilowatts) and micro-generation (10-100 kW).

Most run-of-river hydro in England is micro-generation and is not a waste of time. Our micro-hydro plant (55 kW) will be up and running this year and will generate enough electricity to serve the hamlet where we live. It will save about 140 tonnes of CO_2 per year, offsetting the amount generated by about 14 homes. England has about 20,000 run-of-river mill sites. If these harnessed the maximum potential of each site then up to 1 million homes (4 per cent) in England could be running on renewable electricity generated without upsetting the neighbours.

The whole-life energy harvest factor (ratio of total energy generated to total energy consumed to implement, operate and demolish the plant) for run-of-river micro-hydro is over 40, which is the best of any existing technology.

Bath, Somerset, UK

Ethical meat

From Ian Davis

Speaking as a British beef farmer I agree wholeheartedly with Peter Singer (7 October, p 22). I have always refused to defend both pork and poultry production in the UK on the grounds that to do so was to condone utterly inhumane production systems. Our beef is "single suckled", the system whereby the cows calve in spring and then suckle their calves at grass all summer before the calves are weaned away from their mothers in the autumn and sold on to be reared for slaughter. This is as natural a system as can commercially be made to work,

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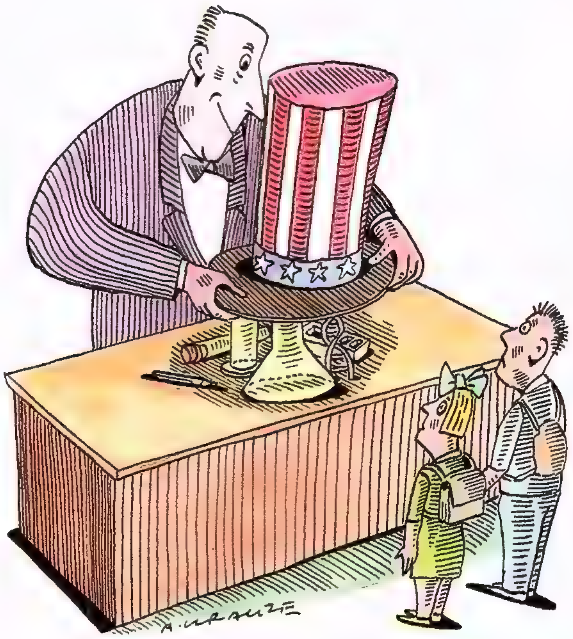
Doing it for the kids

The US has produced a bold blueprint to revitalise its woeful science teaching, but the country will first have to ditch its negative attitude, says **Robert Adler**



IS SCIENCE education in crisis? The US's prestigious National Research Council (NRC) appears to think so. Created by the National Academies to advise the federal government, the council is calling for a major overhaul of how science is taught in America. Its new report, *Taking Science to School*, addresses American students' continuing poor performance in science tests, despite 15 years of reform. In a science test given to 12th graders – 17 and 18-year-olds – in 21 industrialised countries in 1998, the US came 16th. Just 40 per cent of students grasped basic concepts such as the relationship between pressure and volume.

The NRC's report, produced after 18 months of study, is thoughtful and thorough. The authors hope their proposals will help keep the US competitive, prepare students for high-level jobs and, equally importantly, produce citizens with enough scientific savvy to make informed decisions about issues such as stem cell research, climate change and evolution versus intelligent design (ID). But any such measures are likely to fail unless there is a fundamental change in the way science is viewed in the US – starting with the administration.

The US is not alone. The UK's Royal Society has talked of a crisis in science education, and this autumn the British government announced an £18 million programme to encourage more young people to study science, technology, engineering and maths. Yet the US has its own unique problems. With its scientific education failing, the country has relied on large numbers of foreign-born students, scientists and engineers to maintain its momentum in research and technology. However, post-9/11 immigration restrictions have throttled back that influx of talent. According to the World Economic Forum, this was one factor behind the US's unprecedented drop from first to sixth place in economic competitiveness last year.

The NRC has based its proposals on the latest research about how best to teach science, exploiting children's curiosity and observational abilities to develop explanatory and reasoning skills. It also recognises that science teachers need to know and like science, and addresses criticism that compared with other countries, including the UK, science education in the US is "a mile wide but an inch deep". The report proposes that a few core concepts should be taught well, so that students' knowledge and understanding deepens systematically. The authors recognise too the impact of family and culture on how children learn. All in all, it is an impressive piece of work.

However, education does not exist in a vacuum. Even if the NRC's recommendations were widely implemented, science teaching better funded and teachers better trained, it is hard to imagine science education thriving in a nation whose leaders demonstrate an active disdain for the subject. Whether it is the current administration's stranglehold on stem cell research, years of stonewalling the link between human activity and climate change, or the muzzling of leading researchers like James Hansen, director of NASA's Goddard Institute for Space Studies, an anti-scientific bias at the top inevitably trickles down to the grass roots, affecting the myriad intimate interactions between teachers and students that can make or break a scientific education.

"It's hard to see science education thriving in a nation whose leaders actively disdain science"

What conclusions are potential teachers and students likely to draw about the importance of science when scientists' gravest warnings about human-caused climate change are dismissed by political authorities as self-serving exaggerations, and blue-pencilled out of official documents? Or when researchers like Michael Mann of Pennsylvania State University are subpoenaed and grilled by Congress for presenting an "inconvenient truth" (the title of Al Gore's recent film on the subject) about climate change? Or when those same leaders seek to have ID taught in parallel with evolution – if evolution is taught at all? As the authors of *Taking Science to School* point out, at the very heart of science "lies the attitude that data and evidence hold a primary position in deciding any issue".

Unfortunately, it is precisely this point that the current US leadership appears to take issue with. Witness how, encouraged by religious and political leaders – including President Bush – parents and school board members continue to push for the teaching of ID in science classes, and how groups such as Students for Academic Freedom are agitating nationwide for laws authorising students to sue schools or teachers that don't provide equal time for ID and other politicised topics.

The curriculum proposed by the NRC will have to be evaluated state by state, and will stir intense political battles in many of them. I applaud the council's efforts, but I suspect that we will not see any real improvement until scientists, teachers, parents and students receive a very different message from their leaders. The NRC proposes to reform science education from the ground up. That can hardly succeed when science itself is being devalued from the top down. ●

Robert Adler is a science writer based in California and Mexico

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often because they are also more likely to use drugs or alcohol. The findings of the US study are consistent with that hypothesis, as it found that women who had breast implants were more likely than other women to die for reasons related to drug and alcohol use.

A more plausible explanation is that women who receive implants have personality traits or psychiatric disorders that go undetected by surgeons or are ignored by them, and that these put the women at risk of suicide. This view is backed up by the Danish study, which discovered that 8 per cent of women who had breast implants had earlier been admitted to a psychiatric hospital, the most common diagnoses including "neurosis and personality disorders" and "substance or alcohol abuse". Half the women with breast implants who committed suicide had been admitted to a psychiatric hospital before their surgery. It is unclear whether these women were predisposed to suicide and were tipped over the edge by a poor response to cosmetic surgery. "There are some who contend that patients who receive implants demonstrate a host of psychological problems that put them at risk for eventual suicide," says Brinton. "Whether this is the sole explanation or whether patient dissatisfaction after the operation is also involved is not yet clarified."

Another condition that is common among people having cosmetic surgery is body dysmorphic disorder or "imagined ugliness". BDD patients obsess about barely noticeable or non-existent flaws in their physical appearance, and the condition now turns out to affect far more people than previously suspected. A study by Sarwer found that 2.5 per cent of female American college students have BDD. And while there have been no definitive epidemiological studies for the general population in the US, the prevalence is expected to be similar to that in Germany, where a study published this year revealed that between 1 and 2 per cent of the population meet all the diagnostic criteria, and a far higher percentage experience milder versions of the disorder (*Psychological Medicine*, vol 36, p 877). "People seemed puzzled by suicide in women with breast implants, but I would not be surprised if BDD was behind it," Phillips says.

> **"People suffering from body dysmorphic disorder may be 45 times as likely as normal to commit suicide"**

Around three-quarters of people with BDD seek treatments such as cosmetic surgery or dermatological procedures, and an estimated 6 to 15 per cent of cosmetic surgery patients in the US are believed to have BDD. Cosmetic treatment for these people is rarely beneficial and it often makes symptoms worse. "When they are satisfied, which doesn't happen very often, their concerns move on to another body part – this problem is on the inside, not the outside," says Sabine Wilhelm of Harvard Medical School.

The main reason to think that BDD might account for at least some of the unexpected suicides in breast implant patients is the extraordinarily high risk of self-harm among people with BDD. A preliminary study by Phillips's team found that someone with BDD is 45 times as likely as normal to commit suicide (*The American Journal of Psychiatry*, vol 163, p 1280). That is more than twice the rate of people with major depression and three times that of people with bipolar disorder.

To find out whether BDD or some other psychiatric disorder is behind the suicides, and whether cosmetic surgery alters the risks, would require thousands of women to undergo extensive personality testing before and after surgery, something that psychologists and epidemiologists contacted by *New Scientist* doubted will be done. One stumbling block is that cosmetic surgery treatments are not based on rigorous research. "It's a field of artistic endeavour and technique, not research," says McLaughlin. Cosmetic surgery patients tend to be reluctant to volunteer for trials, preferring to remain anonymous. Some women with breast implants don't even tell their husbands that they have had the procedure, says Brinton.

Also, a source of funds for such trials has dried up. In 1999, the US Institute of Medicine effectively cleared silicone implants of causing cancers, immune disorders and other life-threatening diseases. This meant that manufacturers lost an incentive to fund large trials. Add to that the lack of a comprehensive US registry for breast implant patients, or cosmetic surgery patients in general, and it's hard to see such studies ever taking place.

Many cosmetic surgeons do try to screen their patients for "psychological appropriateness", but even they need to be more aware of BDD and other psychiatric conditions, Wilhelm says. "I tell them to look out for what motivates the patient. Don't operate on anyone who thinks the surgery will change their life, or who has unusual or excessive requests for surgery. Focus on their suffering and seek help from a psychologist," Wilhelm says.

For surgeons who are still uncertain, Wilhelm has more advice. "Cosmetic surgery is an elective procedure. Some surgeons say: 'If a patient elects to do it shouldn't I go ahead?' My answer is: 'You as the surgeon can elect not to do it.'" ●

Quest for a perfect body

While it is not yet known whether women get an enduring psychological lift from breast implants (see main story), at least the idea that implants can trigger silicone-induced cancers, autoimmune disorders and other deadly diseases was laid to rest by a US Institute of Medicine Report in 1999.

Yet dangers remain. "Breast implants will not last a lifetime," warns a 2004 pamphlet on silicone and saline implants from the US Food and Drug Administration. "Either because of rupture or other complications, you will probably need to have the implants removed. Many of the changes to your breasts following implantation may be cosmetically undesirable and cannot be reversed."

Despite the graphic photos used to make this point, more than 290,000 women in the US had breast implants in 2005, up 37 per cent from 2000. "I tell these women about all these complications and more, and they still want to do it. They say they want to look better in clothes and feel more confident and less self-conscious. It's a very powerful motivator," says Leroy Young, a plastic surgeon in private practice in St Louis, Missouri.

The desire to perfect your body, even at such high potential cost, is a consequence of living in image-conscious America, says David Sarwer, a clinical psychologist and body-image researcher at the Center for Human Appearance and the University of Pennsylvania School of Medicine in Philadelphia. According to one survey, over 56 per cent of women and 43 per cent of men are dissatisfied with their appearance. "That dissatisfaction motivates a whole host of behaviours – weight loss, cosmetic and fashion purchases, and cosmetic surgery," Sarwer says.

effort and money," says David Sarwer of the Center for Human Appearance and the University of Pennsylvania School of Medicine in Philadelphia. Yet while cosmetic surgery is booming, research into the mental well-being of recipients has not kept pace, says Katharine Phillips, a psychiatrist at Brown Medical School in Providence, Rhode Island.

The results of the few quality studies that have been done are equivocal. Perhaps unsurprisingly, cosmetic surgery patients are more likely than average to have a poor body image. More striking is Sarwer's finding that 18 per cent of a sample of patients having cosmetic surgery were taking drugs to treat a psychiatric condition, typically an antidepressant (*Plastic and Reconstructive Surgery*, vol 114, p 1927). Only 5 per cent of patients undergoing non-cosmetic plastic surgery were taking similar drugs.

That in itself doesn't mean cosmetic surgery is a bad idea, says Sarwer. These patients also invest more than others in their appearance, fitness and health, and the greater use of psychiatric medicines may be a sign that they pay equal attention to their mental health.

Short-term satisfaction

Numerous studies have found that most patients seem satisfied with their procedures, at least in the short term, and surgery might even improve body image. A 2002 study led by Thomas Cash of Old Dominion University in Norfolk, Virginia, found a woman's perception of her body image improves for at least two years after she has had breast implants, while a 2005 study of general cosmetic procedures by Sarwer's team found it improves for at least one year (*Aesthetic Surgery Journal*, vol 25, p 263). Whether such improvements in body image last longer than a few years is not known, and studies of patients' self esteem, depression rates and perceived quality of life are inconclusive.

However, findings from epidemiological studies of a link between cosmetic surgery and suicide are firmer and more disturbing. Five recent studies, including a US study of over 13,000 women who received breast implants and another from Canada of 24,000 (*American Journal of Epidemiology*, vol 164, p 334), set out to investigate the alleged link between silicone breast implants and cancers, autoimmune diseases and other disorders. Though they failed to confirm any such connection, another striking link did emerge: women who have received breast implants are two to three times as likely to kill themselves as those who have not. "The only consistent finding from all the studies has been the unexpected one of suicide," says Joseph K. McLaughlin, director of the International Epidemiology Institute in Rockville, Maryland, who ran some of the studies.

The suicide risk revealed by these studies could turn out to be an underestimate, as deaths due to suicides are frequently attributed to other causes. For example, an update to the US study this year found that women with breast implants also have a higher risk of suffering a fatal road accident and some of those deaths could be suicides, suggests study leader Louise Brinton of the National Cancer Institute in Bethesda, Maryland (*Epidemiology*, vol 17, p 162). Meanwhile, McLaughlin has been re-examining death notices of Swedish women with implants. He says that early indications suggest that suicide may turn out to be even more common than reported in these women (*BMJ*, vol 326, p 527).

Other surgical cosmetic procedures may also be associated with a suicide risk, although it has yet to be quantified for most of them. The largest mortality study, conducted in Canada, found the suicide risk was almost doubled for the 25,000 women who received breast implants and 16,000 women who underwent other cosmetic procedures. A Danish study also found a moderate increase in suicide risk in breast reduction patients (*Archives of Internal Medicine*, vol 164, p 2450).

There is also anecdotal evidence to suggest that it's not just women who are at risk. According to Leroy Young, a plastic surgeon in private practice in St Louis, Missouri, the patients most prone to violence against themselves, and their surgeons, are young, narcissistic males who have had nose or penis surgery. "There's a plastic surgery aphorism – don't operate on the male mid-line," he says.

PHOTODISC

Claims that breast implants cause cancer proved unfounded

SUICIDE RISK

Four major surveys looked at suicide rates for women given cosmetic breast implants

	Number of patients in survey	Suicide deaths		Rate of suicide compared with general population
		Observed	Expected	
US	13,488	19	12.3	1.5
Sweden	3521	15	5.2	2.9
Finland	2166	10	3.1	3.2
Denmark	2761	14	4.6	3.1
All studies	**21,936**	**58**	**25.2**	**2.3**

Trying to get at the reasons behind this increased risk of suicide is difficult. Some commentators even argue that the findings so far may not be relevant to women currently considering breast implants, as most of the women in the studies got their implants decades ago. "It's a very different world now," says James Wells, a plastic surgeon in private practice in Long Beach, California. "The implants are better, how we assess the patients is better, and implant failure rate is lower." This does not reassure epidemiologists such as Brinton and McLaughlin, who have continued to search for clues to what is behind the increased risk of suicide.

One possibility – admittedly very remote, but not yet ruled out – is that leaks from implants can alter women's brain chemistry, triggering suicide in some. Another idea is that women with breast implants commit suicide more

WHEN LOOKS CAN KILL

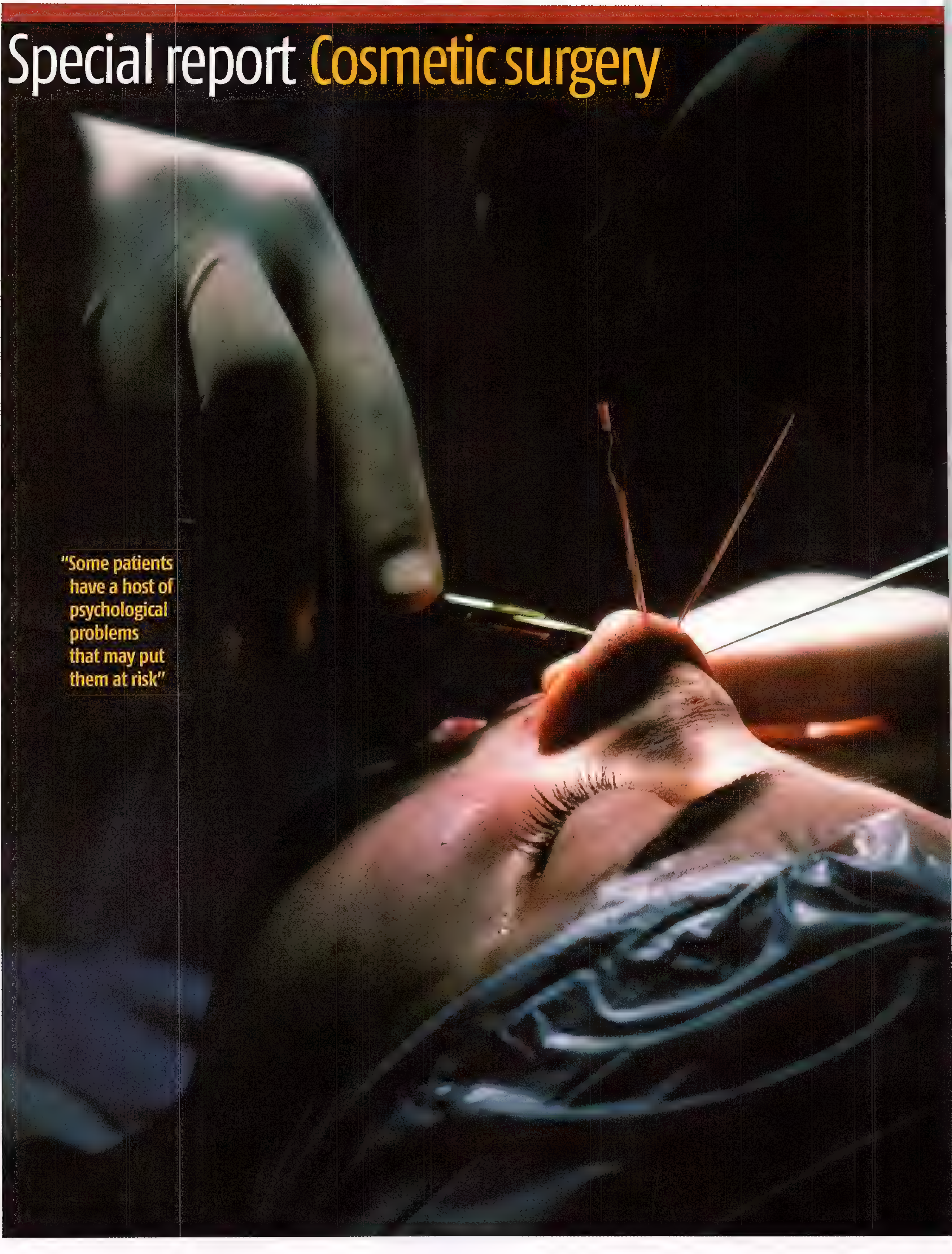
The nip and tuck generation faces a danger far worse than the operation going wrong

RACHEL NOWAK

LAST year, 291,000 American women had bags implanted in their breasts, 324,000 Americans had fat vacuumed out of their bodies, and 231,000 had fat, skin and muscle cut from around their eyes. Add less common operations such as buttock lifts, pectoral implants and vaginal rejuvenations, as well as "minimally invasive" procedures such as Botox injections, and the American Society of Plastic Surgeons estimates that Americans underwent at least 10.2 million cosmetic surgery procedures last year. Cosmetic surgery has gone mainstream.

Like any other surgical procedure, cosmetic operations can never be completely free of risk. Although anyone contemplating cosmetic surgery is likely to have talked over with their surgeon the risks to their physical health, there are some forms of ill health associated with the procedures that are far less likely to be mentioned. In particular, people who go under the knife in the quest for a more attractive body or face are more likely than the average person to be suffering from psychiatric problems. There is mounting evidence that those who choose to undergo cosmetic surgery are more likely to commit suicide. What isn't known is just how much people's mental health is being placed at risk by the burgeoning nip and tuck culture.

A related question is whether cosmetic surgery brings any long-term mental health benefits. After all, implicit in the advertisements and promotional TV shows is the promise not merely of bigger breasts or flatter stomachs, but also the idea of a psychological lift. "We have to believe that cosmetic surgery will improve our self-esteem and body image, and make us feel better about ourselves. If not, we're wasting an awful lot of time, ▶



"Some patients have a host of psychological problems that may put them at risk"

NINA BERMAN/REDUX

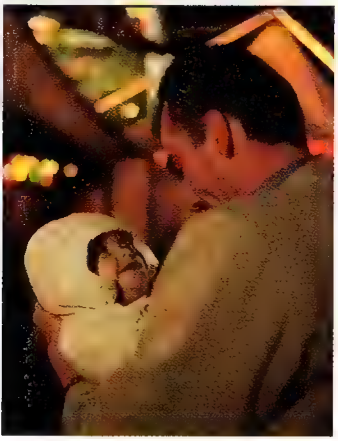
Kids hang on to dad's every word

FATHERS: watch what you say. It seems dads may have more of an influence on their children's language development than they might think.

Lynne Vernon-Feagans at the University of North Carolina, Chapel Hill, and her colleagues sat in on playtime with 92 families with dual incomes, observing how much each parent spoke to their child, the words and sentence structures they used, and the types of questions they asked.

Children whose father's vocabulary was more varied when they were 2 years old had more advanced language skills at age 3. Surprisingly, the dads spoke less and asked fewer questions than the mothers, suggesting it was not how much they spoke but what they said and how they said it that resonated with their children.

The mother's vocabulary did not seem to have a significant impact on language development. However, because most of the mothers in the study used a large number of words when talking to their children, there could also be a threshold at which a large vocabulary ceases to be an advantage to the child, says Vernon-Feagans. "Perhaps when parents' vocabulary falls below such a threshold, as is more likely to occur with fathers in this study, children's later expressive language development may be negatively impacted," she says (*Journal of Applied Developmental Psychology*, DOI: 10.1016/j.appdev.2006.08.003).



JOHANN ROUSSELOT/OEIL PUBLIC

There's not much that's special in organic wheat

IF ORGANIC food really is healthier for you, it almost certainly has nothing to do with its nutritional content. A study comparing wheat grown organically and conventionally found that chemically they were virtually indistinguishable.

"Out of 55 metabolites, only five were statistically different in content," says Christian Zörb of the Federal Research Centre for Nutrition and Food in Detmold, Germany, who led the study team. "Even for those, the difference was less than double between the organic and conventional wheat, and none is known to alter taste or nutritional quality."

Zörb's team studied wheat of a single strain grown with uniform inputs, the only difference being whether the fertiliser used was organic or not. He says that this might give more reliable results than comparing items of unknown history bought from supermarkets (*Journal of Agricultural and Food Chemistry*, vol 54, p 8301).

The yields of organic wheat were 30 per cent lower, which would raise its price, though Zörb accepts that some people may be willing to pay extra for other reasons – to avoid pesticide residues, for example.

Zörb expects similar results with other crops and is now repeating the experiment with potatoes. Peter Melchett of the Soil Association, which represents organic farmers in the UK, says that the difference may be small because the crop rotation used for "conventional" wheat in the experiment was much closer to organic than usual.

Gold rushes to build a gold mine

RARE they may be, but it appears some gold deposits form with surprising alacrity.

At least half of all known deposits formed when hot, pressurised water that had picked up gold elsewhere in the crust fizzled through rock to deposit the metal in veins. It was not clear, though, how concentrated the gold in the water usually is or how quickly deposits can form.

To find out, Stuart Simmons and Kevin Brown from the University of Auckland in New Zealand studied an active deposit at Ladolam on Lihir Island, Papua New Guinea. "It's the only known gold deposit being hosted by the hydrothermal system in which it formed," says Simmons.

They sampled water from up to 1.5 kilometres underground and measured the concentration of gold and the speed at which it is being pushed through the rocks.

From this, they estimate that the 1300 tonnes of gold in the Ladolam deposit built up within about 55,000 years – the blink of an eye in geological terms (*Science*, vol 314, p 288). Simmons says a better understanding of how deposits form should make them easier to find.

CORBIS

Moon and rain could mean quakes

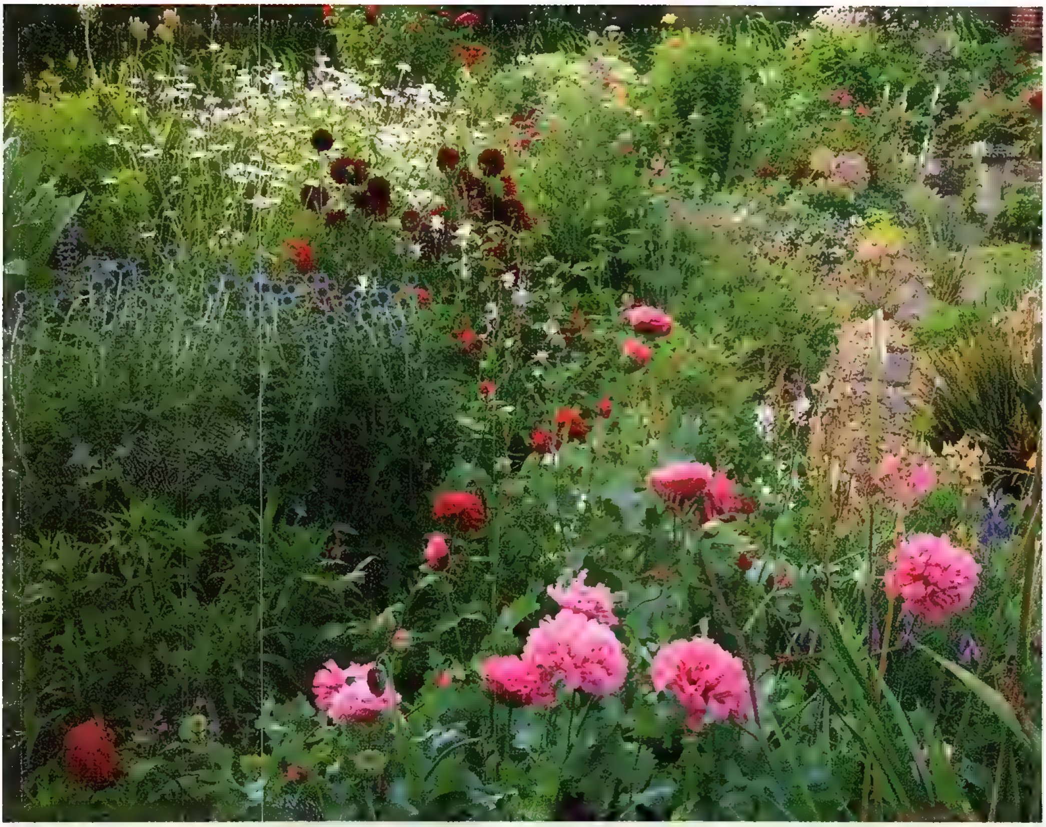
A FULL moon may have triggered the Indian Ocean earthquake that caused the tsunami on 26 December 2004, a new study concludes.

Between October 2004 and August 2005 Robin Crockett from the University of Northampton, UK, and his colleagues monitored tremors and collected tidal data along the Java/Sumatra trench. They found that major quakes were 86 per cent more likely around new and full moons, when tides are at their greatest.

"At new and full moons the biggest mass of water is being loaded and unloaded at the plate boundary," Crockett says. That might be the final push that initiates a quake.

Meanwhile Sebastian Hainzl from the University of Potsdam, Germany, and his colleagues have noticed that rain can also trigger quakes. In 2002 they monitored tremors, rainfall and groundwater pressure in south-east Germany. They found that water from a heavy rainstorm can reach spots underground where masses of rock are trying to move past each other but are stuck together by friction. The water can ease the friction, releasing pent-up tension so that the rocks jerk past each other and initiate tremors as deep as 4 kilometres underground (*Geophysical Research Letters*, DOI: 10.1029/2006GL027074 and 10.1029/2006GL027642).

In brief



MARK BOLTON/CORBIS

Foreign invaders from the past occupy English countryside

INVASIVE species watchdogs have found an unlikely new culprit – 19th century English gardeners. About one-quarter of plants sold to ornamental gardeners since the 1800s have escaped, and 30 per cent of these are firmly established in the English countryside.

Katharina Dehnen-Schmutz of the University of York, UK, and colleagues, scoured seed and plant catalogues from the mid 1800s. They sampled 534 flowers and shrubs on sale and found that the odds of escape increased with how widely available and inexpensive a given plant was at the time. The chances of a plant establishing itself outside the garden depended on biological factors such as the size of a plant's native range and the time since it was first introduced (*Conservation Biology*, DOI: 10.1111/j.1523-1739.2006.00538.x).

The biggest pest singled out by the team was giant hogweed (*Heracleum mantegazzianum*), a flowering plant from south-west Asia that can burn the skin if touched. But Dehnen-Schmutz doesn't think Victorian gardeners should be blamed for the invasions. "At the time, no one knew that these species could spread and cause problems," she says.

Why fat mice are forgetful mice

THEY say we are what we eat. But if we respond to a high-fat diet in the same way as mice, as well as piling on the pounds, we may have to contend with Alzheimer's disease.

Previous studies suggested that high cholesterol levels are a risk factor for the disease, but no one understood why. So Narayan Bhat from the Medical University of South Carolina fed mice a high cholesterol diet for two months. Their working memory declined and their beta amyloid levels went up – this is the protein that forms plaques in the brains of people with Alzheimer's. Mice with a genetic predisposition to high cholesterol levels also had high levels of the rogue protein.

Bhat also noticed increased activity in the microglia – immune cells in the brain associated with inflammation – and higher levels of cytokines, an immune molecule they release. Bhat believes that eating a cholesterol-rich diet triggers an inflammatory response in the brain, which in turn leads to increased build-up of amyloid plaques. This could damage synapses, vital for forming and retaining memories, and may eventually kill brain cells.

The research was presented at a meeting of the Society for Neuroscience in Atlanta, Georgia, this week.

Death sentence

GRAMMAR may have gone out of fashion in English lessons, but it is making a comeback as a weapon for fighting disease.

Some short chains of amino acids have been found to kill antibiotic-resistant pathogens. Gregory Stephanopoulos at the Massachusetts Institute of Technology and his colleagues reasoned that if the amino acid sequences of these peptides were treated as a language with grammatical rules, the rules could be used to create new peptides with similar properties.

The team studied 526 known antimicrobial peptides, looking for clusters of amino acids that often appeared together. They identified 684 of these regular patterns, built a set of rules to describe them and then used the rules to create 42 more peptides. Of these, 20 inhibited the growth of bacteria, including *Staphylococcus aureus* and *Bacillus anthracis* (*Nature*, vol 443, p 867).

Saturn's seething atmosphere

A MYSTERIOUS "string of pearls" has been spotted in Saturn's atmosphere by NASA's Cassini spacecraft. These and other features indicate that the ringed planet's atmosphere is much more active than expected.

Saturn was thought to be placid compared to tempestuous Jupiter, but Cassini's infrared images, cutting through the planet's high-altitude haze, have revealed that it is seething with activity lower down.

The string of pearls formation is made of alternating bright and dark patches, something never seen before. "This is not a boring planet any more," says Kevin Baines of NASA's Jet Propulsion Laboratory in Pasadena, California. "Now the dynamicists have to figure out why it is so active."

NewScientist
Question Everything

JEAN-PIERRE LESCOURRET/CORBIS

Captured, the sweet scent of happiness

ZEEYA MERALI

IT WOULD be the ultimate perfume: a scent that evokes universal happiness. While we're not there yet, a method of identifying scents that provoke the same response in everyone who smells them has brought that ideal a step closer.

For years, sensory scientists had assumed that our reactions to smell were hopelessly entwined with our cultural background. "When I came to the UK I was shocked that the smell of chrysanthemums evokes romantic feelings in people here," says Phillipe Durand, a perfumer at fragrance development company Quest International in Ashford, Kent. "In France we associate it with graves and death."

However, there is mounting evidence from brain scans that our responses to some smells, particularly bad ones, are innate, says Tim Jacob, a smell expert at Cardiff University, UK. "That makes sense because if you had to wait and learn 'this smell kills you' you'd be dead," he says.

To investigate whether our responses to pleasant smells are also hard-wired, John Behan and Anne Churchill from Quest combined measurements of brainwave patterns on EEGs with questionnaires to gauge the responses of people from the UK, France, Germany and Japan while smelling a range of fragrances. "The EEG data is an objective measure of emotional response to fragrance," says Churchill, which is important because verbal response can often be misleading.

They tested around 50 fragrances on between 20 and 30 people. In most cases, while people from the same country identified smells as producing the same feeling, for instance an "invigorating experience", the scans revealed varying levels of brainwave activity related to alertness. Even the fragrance of lavender, which is thought to relax most people, did not produce the same brain response in everyone. "That surprised me," says Churchill, who now believes that emotional responses to these smells are culturally dependent.

There was, however, a subset of "relaxing" fragrances that did produce a consistent pattern across her test group. "The observations are consistent with the idea that while most responses to pleasant smells are learned, some are innate," says Gary Beauchamp, director of the Monell Chemical Senses Center in Philadelphia. "That's exciting."

Behan suggests that in evolutionary terms, sweet and musky smells might fall into the same bracket because they are reminiscent of breastfeeding.

While the technique won't replace the human perfumer, who is still needed to concoct new fragrances, it may help predict which ones will stand the test of time, says sensory psychologist Steve van Toller of the University of Warwick, UK. "Perfumers need to marry fragrance with science if they want to create long-term commercial hits," he says. ●

A HEADACHE FOR PERFUME MAKERS

Chanel No 5 is considered to be the epitome of a timeless fragrance, but its subtleties may have changed over the years. "Regulations introduced since it was created in 1921 have forced many of the original ingredients out of the perfumer's palette," says John Ayres, Chairman of Fragrance Foundation UK, in London. If new European legislation is passed in December, other cosmetics may have to be reformulated or removed from the shelves entirely.

Last week, members of the European parliament's environment committee voted in favour of a draft version of Registration, Evaluation, Authorisation and Restriction of Chemicals. REACH calls for manufacturers importing more than 1 tonne of a chemical substance per year to test it for safety and then register it in a central database.

Many chemical manufacturers worry that this will force them to retest chemicals they have been using safely for years. Smaller companies may have to stop producing some cosmetics ingredients completely because they are unable to afford the tests, warns Chris Flowers of the Cosmetic Toiletry and Perfumery Association in London. "Inevitably, there will be a range of everyday products that suddenly won't be available on the shelves because we won't be able to make them," he says.

REACH has to pass two more rounds of voting before it can become law, so modifications could still be made.

THIS WEEK 30 YEARS AGO

Pirates on TV

The possible hijacking of a television channel at peak time by a pirate TV programme is giving television authorities real concern. Similar events have already taken place on a minor scale in Britain and France with the BBC being embarrassed by publicity given to an April Fool's Day takeover of its Radio 1 transmitter on the Isle of Wight. Britain's Independent Broadcasting Authority started to worry after two minutes of pornography was inserted into a French TV programme.

Both the BBC and the IBA admit that a repeat of the French incident could hit the screens of British viewers. At present, almost all sub-transmitters that pass on signals are unattended. This means both authorities are powerless to stop such interference. While transmitters have alarm signals to indicate major failures, they only react if the vision or sound signals vanish, not if the signal is replaced but still of high quality.

In such a case a short pirate programme could be broadcast because it would depend on local TV viewers phoning engineers when the pirate station appeared. It might be up to 10 minutes before engineers could react. In remote districts any remedial action could take hours.

The BBC is now building in security systems, including a new possible defence called the Insertion Test Signal which uses encoded information in spare and unseen lines of the TV picture to guarantee the signal's authenticity. However, the possibility of alternative TV appearing on our screens before next April Fool's Day is far from remote.

From *New Scientist*, 21 October 1976

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407

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PEU5726/NS

'Deep Impact II' to blow Europa's cover

DAVID L. CHANDLER

THE Deep Impact mission, which last year fired a massive projectile at the nucleus of comet Tempel 1, has inspired a proposal for a similar mission to Jupiter's moon Europa.

Evidence that Europa has a subsurface ocean, which would make it the only known "water world" besides Earth, emerged between 1996 and 2003 from NASA's Galileo mission. While this makes Europa a prime target in the search for alien life, any plan to reach its ocean faces the daunting challenge of how to drill or melt down through the 20 kilometres or more of ice lying above it.

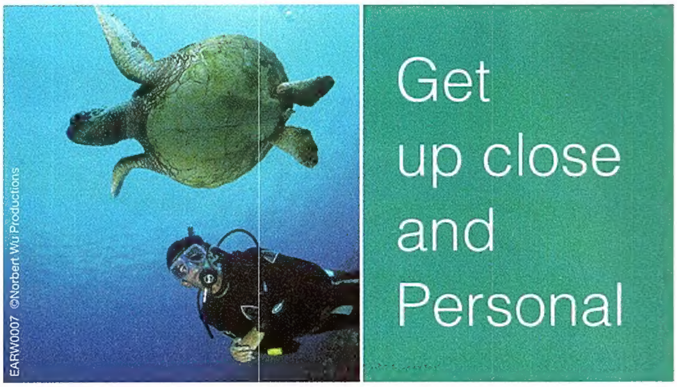
To begin to tackle the problem, a team led by researchers at Johns Hopkins University in Baltimore, Maryland, is proposing to smash a spacecraft into the ice and analyse the plume of ejected material. While the impact would come nowhere near breaking through to the ocean below, the energy released would throw up a tonne of material for every gram that the craft itself weighed.

This would provide the best chance of measuring the true composition of Europa's ice, potentially revealing the residue of life or its precursor molecules. The probe would "dig into pristine dirt and analyse that stuff for organics", says Karl Hibbits of the Applied Physics Laboratory at Johns Hopkins.

Getting below Europa's surface is necessary for the task, as the top layer of ice has been chemically altered by radiation caused by Jupiter's powerful magnetic field, and by constant sputtering from volcanic eruptions on the neighbouring moon Io. Because of these changes, "astrobiology can't do anything useful at the surface", says Louise Prockter, also at Johns Hopkins. Using an "impactor" craft would also avoid the problem of radiation destroying a lander and its instruments during an extended operation on the surface.

The proposal, outlined last week at a meeting of the American Astronomical Society's Division for Planetary Sciences in Pasadena, California, envisages that the impactor would have a camera and transmitter to get close-up pictures during the descent. As with the Deep Impact mission, a separate fly-by spacecraft would do a spectroscopic analysis of the impact plume, go into orbit around Jupiter and loop back to take pictures of the crater. "It's quite an elegant way to look at a very difficult problem," says Prockter. The same concept could be used for exploring other icy bodies such as Neptune's huge moon Triton, the team says.

Funds even just to develop the proposal will be a problem. As a stand-alone mission, it would cost about a billion dollars, and NASA has no development funding for such missions. "The axe hit" when NASA cut back on science funding this year, says team member Peter Schultz of Brown University in Rhode Island. An initial proposal to NASA was turned down this year, but the group hopes to find other sources of funding to pursue the research and then resubmit the plan. One possibility is to make it a component of NASA's planned Juno mission, now set for launch around 2011. ●



Instead of just watching and learning about wild creatures from the comfort of your sitting room or searching in vain for a unique, tourist free travel destination you could join an Earthwatch field research expedition. You'll find out what its really like to get up close to animals in the wild and see places that aren't in any travel brochure – from working with sea turtles to the remote deserts of Australia. Joining Earthwatch as a paying volunteer means you'll be making a very personal contribution to the survival of many of our best loved species and helping to preserve some of the most beautiful wild places in the world. Past Earthwatch volunteers have recently helped create an important marine sanctuary for dolphins in Spain and protected forests in Canada. We now need volunteers for many more international and local expeditions. No experience or special skills are required just a willingness to get involved and a desire to have a once in a lifetime experience.

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SOUNDBITES

“It's a part of life, it's fun to have sex... Bonobos are bisexuals, all of them.”

Geir Soeli, project leader of an exhibition about animal homosexuality called "Against Nature?" at the Oslo Natural History Museum, Norway, which concludes that human homosexuality cannot be viewed as unnatural (Reuters, 16 October)

“Our evaluation is that the food from cloned animals is as safe as the food we eat every day.”

Stephen Sundlof, chief of veterinary medicine at the US Food and Drug Administration, which is set to approve milk and meat from cloned animals for human consumption by the end of the year (*The Washington Post*, 17 October)

“If the Korean astronaut eats our traditional food in space, it will be a great opportunity to show off our nation's culinary culture, specifically the greatness of kimchi.”

Kim Sung-soo of the Korea Food Research Institute on the menu – including pickled cabbage – planned for the voyage of South Korea's first astronaut in 2008 (*The Chosun Ilbo*, Seoul, 17 October)

“Our ambition is to supply enough electricity for automatic ticket [barriers] and display panels in the future.”

Takahiro Kikuchi of Japan Railways on plans to use energy from commuters' footsteps to generate electricity (*The Japan Times*, 17 October)

“I am doing all this because I want to confirm my identity as the daughter of Juan Perón. It is my human right.”

Martha Holgado, 72, on having DNA extracted from the body of the former Argentine leader in order to perform a paternity test (*The Daily Telegraph*, London, 17 October)

Where the early detection of cancer helps you enjoy a longer life and Asia's first Keystone Symposia brought breakthroughs in stem cell research to the world.

SINGAPORE

WHERE GREAT THINGS HAPPEN

Asia's first Keystone Symposia convened scientists to exchange findings on stem cell research and served to accelerate applications that benefit medical science. Singapore is home to the global manufacturing facilities of eight leading pharmaceutical companies. Drug discovery and development laboratories of numerous biomedical sciences companies are also present here. A city that brings together global scientific leaders, Singapore is known for its world-class research infrastructure while its vibrant cityscape and unique culture provide enriching experiences for visitors. Choose Singapore for your corporate meetings, conferences, exhibitions and incentive travel. **visitsingapore.com/businessevents**

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